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The contextualisation of Crusader mass graves from Sidon, Lebanon

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Abstract

The reliability of historical accounts regarding the number and nature of battles, sieges and smaller conflicts during the Late Medieval period (AD1000-1500) is hotly debated due to the relative lack of physical evidence for these events and processes. The Crusades in the Levant have been extensively studied from the perspective of the rich archive of historical records pertaining to the period. Yet, rarely have these violent times been studied from the most direct and incontrovertible evidence for them: the human remains of those directly involved.

Data collected from human remains recovered from stratigraphically secure deposits dating to the Crusader period (1095-1291 CE) at College Site, Sidon, Lebanon provide rare insight into the nature and process of Late Medieval warfare in the Levant, including the identity and origins of those individuals directly involved in conflict, with specific hypotheses developed:

1. All individuals represented in the deposits died in a closely contemporary context if not a single event.

2. All individuals belonged to the same social group (i.e. Christians resident in Sidon at the time of their deaths.

To test these hypotheses, a multidisciplinary, bioarchaeological approach was taken, applying macroscopic observation of the skeletal remains, isotopic studies (strontium, oxygen, carbon and nitrogen) and radiocarbon dating; alongside evidence from the archaeological context and a review of the contemporary historical sources.

Results demonstrate: the assemblage represents a minimum of 25 individuals; the two deposits are contemporary and most likely relate to a single final depositional process; the profile of the assemblage is consistent with a military or conflict-related context (i.e. all male, with the age range including older adolescents to mature adults); the assemblage represents a mixed group with varying backgrounds, including both probable locals and non-locals in addition to a differentiated group who may represent individuals from the Near East with a different strontium signature to the locality of Sidon.; finally, the pattern of trauma confirms intensity of late medieval warfare in the Near East and the presence of recidivists.

This study presents data from the largest conflict-related mass grave (MNI = 25) directly dated to the period of the Crusades in the Latin East yet to come to light. This research provides a wider understanding of Late Medieval warfare and of the Crusades in the Levant; advances understanding of the nature of urban and siege warfare during the Crusades in the Latin East; highlights the importance of integrating bioanthropological analyses with broader contextual data from both archaeological evidence and historical sources; contributes to the osteological and palaeopathological record for Lebanon; and finally contributes to the reassessment of current thinking on Late Medieval warfare and associated mortuary processes and supports the development of an improved theoretical framework for its interpretation.

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My supervisor Professor Holger Schutkowski first presented me with the opportunity to go to Lebanon in 2003. Taking up his offer, little did I realise I would still be excavating in Sidon over sixteen years later and it is not difficult to state that this cumulative experience has shaped a good part of my life. It has been a pleasure and a privilege to work with Professor Schutkowski to bring this research to fruition and I am most grateful for his faith, encouragement and support throughout my time at Bournemouth. It is an extremely rare occurrence for an archaeologist or osteologist to be involved with research material from the point of excavation through multidisciplinary analyses and on to publication. Yet here I am. Thank you Holger.

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Declaration

I declare that this thesis contains no material that has been accepted for the award of any other degree or diploma in any institution or university. The thesis is based on my original work except for quotations and citations which have been acknowledged accordingly. I also declare that this thesis has not been previously or simultaneously submitted, either partially or wholly, for any other qualification at any university or institution.

Richard N. R. Mikulski

August, 2019

1 INTRODUCTION

1.1 Chapter Introduction

The Crusades to the Near East form one of the most studied series of events of the Middle Ages, yet despite the strong focus from both academic researchers and the general public on this period of history, there remain significant gaps in our knowledge. The evidence upon which insights are based remains open to conjecture, the vast majority of such being almost exclusively derived from the written, artistic and architectural sources. The current study is therefore both novel and significant in presenting observations deriving from a line of evidence that has received considerably less attention to date – the physical remains of those people actually participating in or directly impacted by the events.

The current research aims to address the comparative lack of direct evidence pertaining to the violent nature of medieval and specifically crusader warfare and its immediate consequences. It examines the evidence for physical conflict within this specific historical and geographical context and to investigate how such hostilities and aggression are reflected in the formation and preservation of the archaeological record.

1.2 The Investigation of Warfare and Violence

Despite the large number of historical accounts pertaining to the many named battles and innumerable smaller skirmishes during the Late Medieval period in Europe and the Eastern Mediterranean (Boylston, 2000; Crawford, 2003; Gabrieli, 1984; Marshall, 1996; Mitchell, 1999; Runciman, 2016a, 2016b, 2016c; Shirley, 1999; Smail, 1956; Sutherland and Schmidt, 2003), very little evidence for the physical consequences of such actions has hitherto been located or reported. Keeley in his book *War before Civilisation* (1997) has argued that significant evidence for war in prehistory has been over-looked or neglected. It could be argued that this issue extends into more recent and historically documented periods where direct evidence for past violence as manifested by human remains has often received less attention than other less direct sources of evidence (such as weapons and historical accounts). Such issues may extend into and even be compounded during the modern era, where recent examples demonstrate attempts to deliberately hide, obscure or destroy evidence of conflict and its consequences (Ríos et al., 2010, 2012; Vanezis, 1999).

The largest group of mass burial contexts so far identified and investigated which can be directly linked with a historically documented battle of the Late Medieval period derive from the Battle of Wisby in 1361 (Courville, 1965; Ingelmark, 1939; Thordeman, 1939). When remains which derive from such large-scale battles have been identified and excavated, the study of mass grave contexts has previously been rather limited in scope, focussing on the material remains, weapons and armour associated with the bodies of the fallen, as demonstrated by Thordeman's publication *Armour from the Battle of Wisby, 1361* (1939). As the title suggests, the skeletal remains often received considerably less attention during this early period of battlefield archaeology, except to confirm textual sources (Knüsel and Smith, 2013a: 7).

More recently, with the development of biological anthropology and osteoarchaeology, and in addition, the refinement of archaeological recording techniques, much greater insight has been gained from the human remains derived from such unusual contexts (Knüsel and Boylston, 2007; Sutherland and Schmidt, 2003; Fiorato et al., 2007). Alongside multidisciplinary investigations of individual burials with interesting taphonomic histories (Lamb et al., 2014; Melton et al., 2013; Roffey et al., 2017), such studies have also provided new knowledge concerning the broader societies from which human remains derive, informing us about individual levels of activity in everyday life, military training, army recruitment, developing weapon technology and military tactics, and the consequences of battle for burial traditions.

At the same time, interest in the human propensity for violence has gained steady momentum over the last hundred years. Initial theory regarding the development of warfare polarised into two camps: one focussed on the idea that humans are innately war-like, as characterised by Thomas Hobbes in his 1651 publication of *Leviathan* (Brooke, 2017:102); the second insistent that warfare had emerged in parallel with development of civilisation, as based on *The Social Contract* (Rousseau, [1762], 2012: 15). During the first half of the 20th century, anthropologists generally followed the latter, explaining the manifestation of violence and warfare as a consequence of developing civilisation and increasing technological sophistication. The evidence for organised conflict was clear and present during this period, yet it appeared to such early anthropologists as Chapple and Coon, that early and/or non-state-based cultures, with their limited resources, basic technologies and observed behaviour (as characterised by interpretations of archaeological evidence and ethnographic accounts), were incapable of achieving such levels of violence and destruction (cited in Otterbein, 1999: 796).

These observations and early reports of such cultures resulted in the development of the 'myth of the peaceful savage'. Only by the end of the 20th century, had anthropologists and archaeologists begun to reassess the evidence and question this assumption. Keeley's incisive 1997 publication essentially threw out this view, providing ample evidence that warfare had in fact been present throughout prehistory across the world. Instead, a new theory was put forward, proposing that warfare was a social response or strategy, precipitated by certain conditions or circumstances (Keeley, 1997; Otterbein, 1999; Vandkilde, 2003). More recently, Worne et al. (2013: 141) have described warfare as "a cultural process that has significant ramifications for many aspects of everyday life".

A problem, particularly associated with the investigation of its origins, is how we define war. In contrast to Kelly's restrictive multi-point scheme (Kelly, 2000), Thorpe (2003: 146) advocates a looser definition, characterising warfare as: *"… organised aggression between autonomous political units.*". Bishop and Knüsel (2005), again concentrating on the prehistoric period, although with reference to historic evidence also, base their research on the following definition:

> *"…any prolonged conflict between two [or more] rival political groups by force of arms…"*

(Montgomery (1968: 11)

It has been noted, however, that 'political groups' could be replaced by other types of group, as defined by ethnicity, religion or other commonalities and shared interests (Bishop and Knüsel, 2005). The problem of definition is crystallised in attempts to distinguish between domestic or interpersonal violence within a group and inter-group conflict, the latter of which can range from inter-family feuds to tribal raids to civil conflict to international, multi-landscape global war.

The anthropological perspective and its focus on human violence naturally overlaps with the relatively new field of conflict archaeology, a catch-all term which has become mainstream over the last twenty years, following recognition of the wide variety and complexity of evidence for human conflict and its many different types and scales of manifestations. On a broader scale, the integration of evidence from human remains into long-term, 'big-picture' narratives has also been neglected. Larsen (1997) and Buikstra and Beck (2006) have emphasised the importance of synthesis between the evidence from human remains, their archaeological context and social theory. In considering the evidence for conflict within the archaeological record and with specific reference to human remains, three recent edited volumes have sought to address the problems raised by a wide variety of independent research and site-specific reports, tackling the issues of both time-scale and geographic region. The first two of these focus on either regional and/or temporal trends:

Nichols and Crown (2008) provide a regional perspective on the American Southwest, and Schulting and Fibiger's (2012a) volume focuses on violence in Neolithic Europe. The latter has provided some suggestions for how to incorporate human remains within studies of violence and advocates some specific theoretical propositions. For example, Schulting and Fibiger (2012b) add their support to previous authors such as Lovell (1997) and Neves et al. (1999) who advocate the 'hat-brim rule' (Galloway, 1999a; Kremer et al., 2008; Spitz, 1993): that infra-cranial trauma is more likely to be a result of accident than of interpersonal violence, whilst cranial trauma and especially weapon-induced trauma, are often associated with interpersonal or inter-group violence. The authors also suggest a focus on the identification and quantification of cranial trauma alongside defensive injuries (e.g. 'parry' fractures - see Judd, 2008), thereby providing comparable data across a broad geographical range. Furthermore, in their introduction, Schulting and Fibiger (2012b) highlight problems of interpretation and the ambiguous nature of skeletal trauma, stressing that the analysis of wound patterning, particularly alongside other evidence for violent confrontation can go some way to resolve this ambiguity (e.g. Judd, 2008).

Finally, Knüsel and Smith (2013b) provide a substantial overview of the bioarchaeology of pre-modern conflict, spanning approximately 130,000 years and incorporating case studies from both Old and New Worlds, with an emphasis on interpretation of remains in parallel to consideration of their chronological, geographical and social context. This represents the most comprehensive reference volume and source of comparative data to date.

The current research will commence filling in the gap in our knowledge concerning the immediate consequences of conflict in the Levant during the Crusader period. For the first time, a detailed, multidisciplinary study will be carried out on a group of well- stratified human remains from a mass grave context derived from the Crusader period, a historical context about which we know very little beyond the limited evidence of the few contemporary historians who wrote about it. It aims to elucidate identity of the individuals under study and the context in which they died and were deposited. In so doing, it will demonstrate how bioarchaeological evidence from human remains can be used to complement the historical sources and archaeological context in investigations of the Crusades and the lives of those directly involved or affected by these tumultuous times.

1.3 History of Research on the Crusades

To date, much of the investigation of late medieval warfare has been almost exclusively reliant upon the historical accounts and records pertaining to military affairs, particularly when considering the Crusades in the Levant. Such records – and subsequent studies of them – have tended to focus on the major conflicts of this period, to the neglect of smaller-scale violent encounters. In Britain, it has been suggested that the latter are likely to have been exponentially greater in number (The UK Battlefields Trust, 2010), and it seems quite possible that this was also the case in such contentious regions as the Frankish states in the Latin East during the Crusades.

The vast majority of crusader period research has concentrated on the material culture (Boas, 1999, 2010; Pringle, 1985, 1986, 1997; Stern, 1999; 2015; 2018; Stern and Waksman, 2003) of, and the historical sources pertaining to, these historically-significant times of conflict and change (Crawford, 2003). More specifically, the architecture of crusader period settlements and fortifications has received particular focus (Ayalon et al., 2013; Ellenblum, 2001; 2003; Ellenblum e al., 1996; Harper and Pringle, 2000; Kennedy, 1994; Lawrence, 1988; Pringle, 1986, 1987, 2000).

The long trajectory of the historical perspective consists of simple narratives or, more recently, of discursive transactions concerning the motivations and practical logistics which respectively drove and facilitated the crusading phenomenon (Smail, 1956; Marshall, 1996). Such later research has concentrated on the following categories of evidence in particular: evidence for military organisation; military architecture; historical accounting records; and contemporary witness (primary) and secondary accounts of events.

In contrast, investigations of the skeletal human remains of those participating in crusades have been extremely limited, mainly due to their scarcity. Until now only very few studies have been published, focussing on the crusader era cemetery populations of the port cities of Acre (Akko) and Caesarea (Mitchell, 2006a; Mitchell and Millard, 2009; Mitchell et al., 2008) and the small rural Christian cemetery at Parvum Gerinum/Le Petit Gerin (see Bradley, 1994; Mitchell, 1999, 2006b; Mitchell and Millard, 2009).

Only a single report of skeletal remains relating to a recorded conflict event is known for the Latin East, concerning remains thought associated with the siege of Vadum Iacob (Mitchell et al., 2006).

1.4 Warfare in the Medieval Latin East

Warfare and its context in the Latin East varied from that traditionally practised in northwestern Europe. Environmental conditions, most obviously the higher temperatures, represented problems which influenced the equipment and tactics of the crusading forces. These were also subject to the behaviour and fighting style of new and unfamiliar enemies who were typically much more mobile than western armies (see William of Tyre's description below). Yet, Marshall argues there is little evidence to suggest western Crusaders altered their arms or armour to account for these issues, even by the latter phases of the crusader period in the 13th century (Marshall, 1996: 86).

In contrast, France (2000: 49) states that western Franks settling in the Eastern Mediterranean, 'very substantially modified their style of war', although he focusses more on the Crusaders' strategic approach and their political and social relations, rather than their physical fighting style and tactics. Yet France does provide good argument for adaptations within the make-up of crusader armies, pointing to the inferred introduction of light and heavy cavalry as represented by distinctions made between sergeants à cheval and knights by the end of the crusader period (France, 2000: 51). He also notes that evidence from broadly contemporary manuscript illuminations demonstrate little distinction between eastern and western Franks in their equipment (France, 2000: 55).

Much of what we know and understand concerning medieval warfare and more specifically crusader warfare, is derived from historical sources, contemporary accounts and pictorial or iconographic representations, written and produced sometimes by those who took an active part in the combat but more often, by those living in places or time periods far removed from the events they describe. Notwithstanding such caveats, these documents and representations provide an important starting point from which to investigate and evaluate the evidence for warfare in this period. Crusader warfare is served relatively well in this regard, with a range of contemporary sources, both written and visual, in addition to rare examples of the sometimes very specific material culture recovered from archaeologically-recorded deposits which developed in the Frankish States in the Latin East.

During the 20th century, two historians in particular produced seminal works dealing with aspects of crusader warfare in the Levant. Smail (1956) focussed on events of the First and Third Crusades and consequently is rooted in the 12th century. He deals with specific elements of warfare such as the ethnic make-up of the Crusaders, crusader policy in Syria, the recruitment, organisation and tactics of the opposing armies, as well as the functions and forms of Crusader castles.

The second half of the Crusader period, constituting the tail end of the 12th century and almost the entirety of the 13th century, is dealt with in a similar fashion by Marshall (1996). This volume is more concerned with the military engagements themselves, reflecting their variety and how they varied in scale from pitched battles involving thousands to small raids of perhaps no more than a dozen; evidence for the latter appears more widespread in this period, although such activities were likely just as prevalent during the preceding century.

During both the 12th and 13th centuries, battles in the field took essentially one of two forms: either pitched battle (e.g. Hattin) or 'running' battles which took place whilst on the march and typically favoured the mobility of light cavalry that included mounted archers (Smail, 1956: 140, 156-197; Marshall, 1996). Marshall (1996: 146) also notes, however, that contemporary historians may sometimes have recorded events relating to siege activity (e.g. sorties), as battles.

Different groups appear to have had specialised warfare and tactics, often focussing on their specific skills and resources. For example, during the early period of the Crusades in the Near East, the tactics of the Seljuk Turks (whom the Crusaders fought on their way across Asia Minor) focussed on their mobility and use of a specialist 'Turkish' bow:

> *"[The Turk] surrounded our men and shot such a great number of arrows and quarrels that rain or hail never darkened the sky so much and many of our men and horses were injured. When the first bands of Turks had emptied their quivers and shot all their arrows, they withdrew but a second band immediately came from behind where there were yet more Turks. These fired even more thickly than the others had done… [after this preparatory phase, decisive action followed:] The Turk, seeing that our men and horses were severely wounded and in great difficulties, hung their bows instantly on their left arms under their armpits and immediately fell upon them in a very cruel fashion with maces and swords."*

(William of Tyre, 12th century, [Ch.14] in Babcock and Krey, 1943, Vol. I: 170-171; see also Smail, 1956: 76, n.9 and Contamine, 1984: 60)

The Eastern armies generally appear to have been reluctant to engage the Frankish forces in open battle unless they were confident of victory – or rather when the state of their forces was significantly stronger and/or greater in number than their opponents. Muslim tactics favoured narrow spaces or topography which limited or hindered the movement of the feared Frankish heavy cavalry. Usāma ibn Munqidh, an amīr of the 12th century, recounts an instance of incitement of his tutor, Abū ʻAbdallāh ibn al- Munīra to join battle:

> *"O Professor, if thou should'st put on a jerkin with a helmet, dangle a sword at thy side, carry a lance and a shield and stand by the Mashhad al-'Āṣī (a narrow place where the Franks - may Allah's curse be upon them! – used to cross the river), not one of them would dare pass by thee".*

(Usāma ibn Munqidh, 12th century, in Hitti, 1964: 114; see also Nicolle, 1979: 164)

Other examples of the eastern forces using narrow/restricted areas to confound the Crusaders include the westerners' heavy defeat at Gaza in November 1239. Although stemming from the ill-advised and poorly coordinated nature of this raiding expedition, the Crusaders' defeat was ultimately inflicted through Rukn al-Din's use of the local topography which provided him strategic advantage and inhibited the western cavalry's ability to manoeuvre (Rothelin Continuation, 13th century, in Shirley, 1999: 48). Once victory appeared certain, their cavalry would close in, setting aside their bows in preference for weapons more practical in close combat, typically including spears, swords and maces (Nicolle and Mcbride, 1986: 7).

1.4.1 Latin siege warfare

However, as in Europe, sieges and their associated events constituted the majority of military actions in Western Asia, throughout the time period of the Crusader States. There are numerous historical accounts of extended sieges during the late medieval period both in Europe and the Levant, providing details of the various activities of both defenders and besiegers. Hewitt (1860: 355-360) cites the letter of Guillaume des Ormes, Seneschal of Carcassonne, to Queen Blanche, (mother of Louis IX and regent in his absence), which provides an extended account of the unsuccessful siege in Autumn 1240. Closer to the context of Sidon, Giles (1847) provides a translation of William of Malmesbury's account of the siege of Jerusalem, at the climax of the First Crusade in 1099:

"There was one engine which we call the Sow, the ancients, Vinea; because the machine, which is constructed of slight timbers, the roof covered with boards and wicker-work, and the sides defended with undressed hides, protects those who are within it, who, after the manner of a sow, proceed to undermine the foundations of the walls. There was another, which, for want of timber, was but a moderate sized tower, constructed after the manner of houses: they call it Berefreid: this was intended to equal the walls in height. The making of this machine delayed the siege, on account of the unskilfulness of the workmen and the scarcity of the wood. And now the fourteenth day of July arrived, when some began to undermine the wall with the sows, others to move forward the tower. To do this more conveniently, they took it toward the works in separate pieces, and, putting it together again at such a distance as to be out of bowshot, advanced it on wheels nearly close to the wall. In the meantime the slingers with stones, the archers with arrows, and the cross-bow-men with bolts, each intent on his own department, began to press forward and dislodge their opponents from the ramparts; soldiers, too, unmatched in courage, ascend the tower, waging nearly equal war against the enemy with missile weapons and with stones. Nor, indeed, were our foes at all remiss; but trusting their whole security to their valour, they poured down boiling grease and oil upon the tower, and slung stones on the soldiers, rejoicing in the completion of their desires by the destruction of multitudes. During the whole of that day the battle was such that neither party seemed to think they had been worsted; On the following, which was the fifteenth of July, the business was decided. For the Franks, becoming more experienced from the event of the attack of the preceding day, threw faggots flaming with oil on a tower adjoining the wall, and on the party who defended it, which, blazing by the action of the wind, first seized the timber and then the stones, and drove off the garrison. Moreover the beams which the Turks had left hanging down from the walls in order that, being forcibly drawn back, they might, by their recoil, batter the tower in pieces in case it should advance too near, were by the Franks dragged to them, by cutting away the ropes; and being placed from the engine to the wall, and covered with hurdles, they formed a bridge of communication from the ramparts to the tower. Thus what the infidels had contrived for their defence became the means of their destruction; for then the enemy, dismayed by the

smoking masses of flame and by the courage of our soldiers, began to give way. These advancing on the wall, and thence into the city, manifested the excess of their joy by the strenuousness of their exertions."

(William of Malmesbury, 12th century, in Giles, 1847: 388-389)

Other sources for such sieges and warfare in the Near East include iconographic evidence, such as illuminated manuscripts closely contemporary with the period. For example, a manuscript attributed to William of Tyre (possibly a later copy), provides an illustration of the storming of Jerusalem in 1099 (Figure 1). The Maciejowski Bible (Figure 2 and Figure 3), thought to have been produced in the 1240s, depicts Old Testament scenes using contemporary material culture. These images constitute important sources for the use and development of weapons, armour, tactics and context of late medieval warfare in the Latin East.

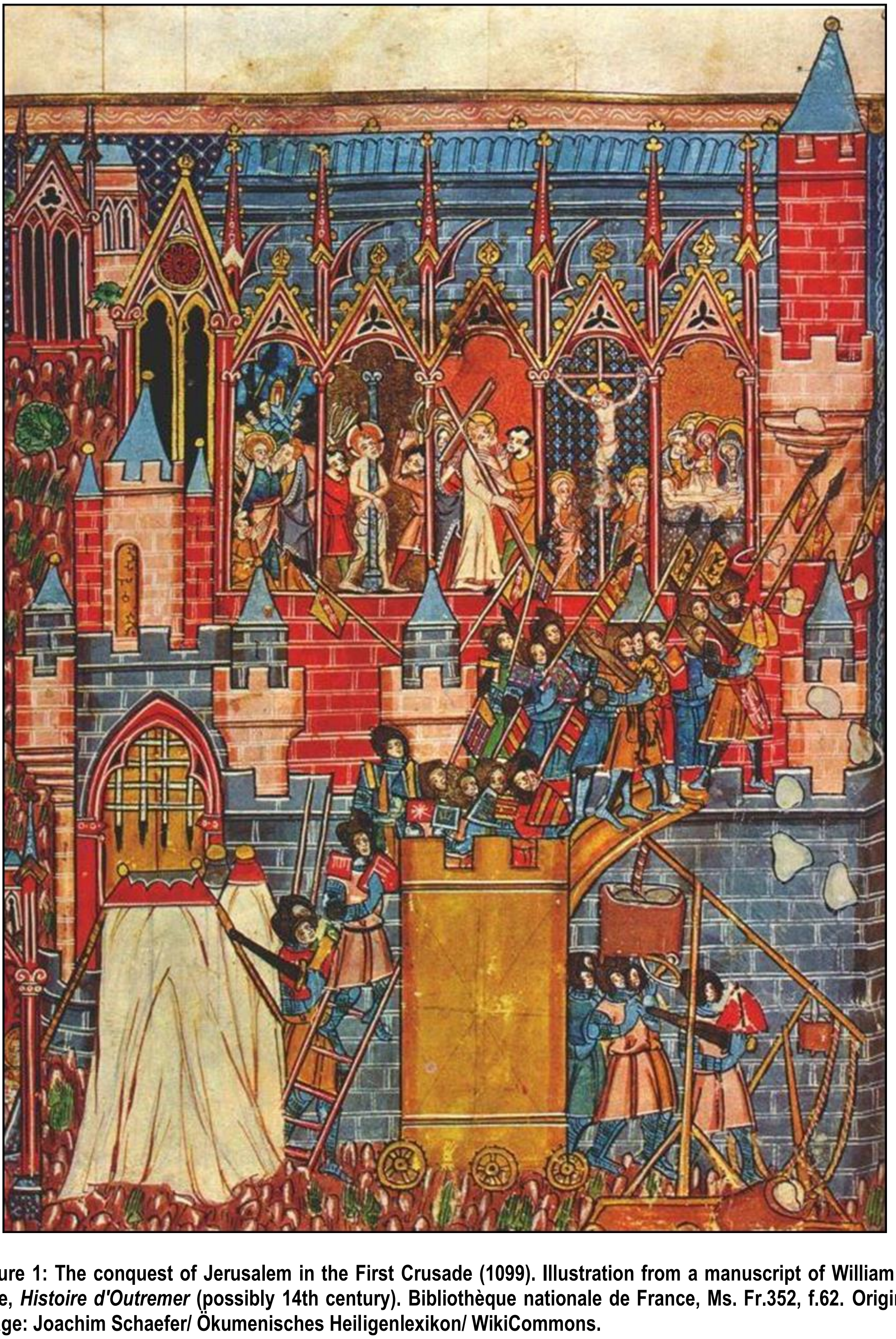

Figure 1: The conquest of Jerusalem in the First Crusade (1099). Illustration from a manuscript of William of Tyre, *Histoire d'Outremer* (possibly 14th century). Bibliothèque nationale de France, Ms. Fr.352, f.62. Original image: Joachim Schaefer/ Ökumenisches Heiligenlexikon/ WikiCommons.

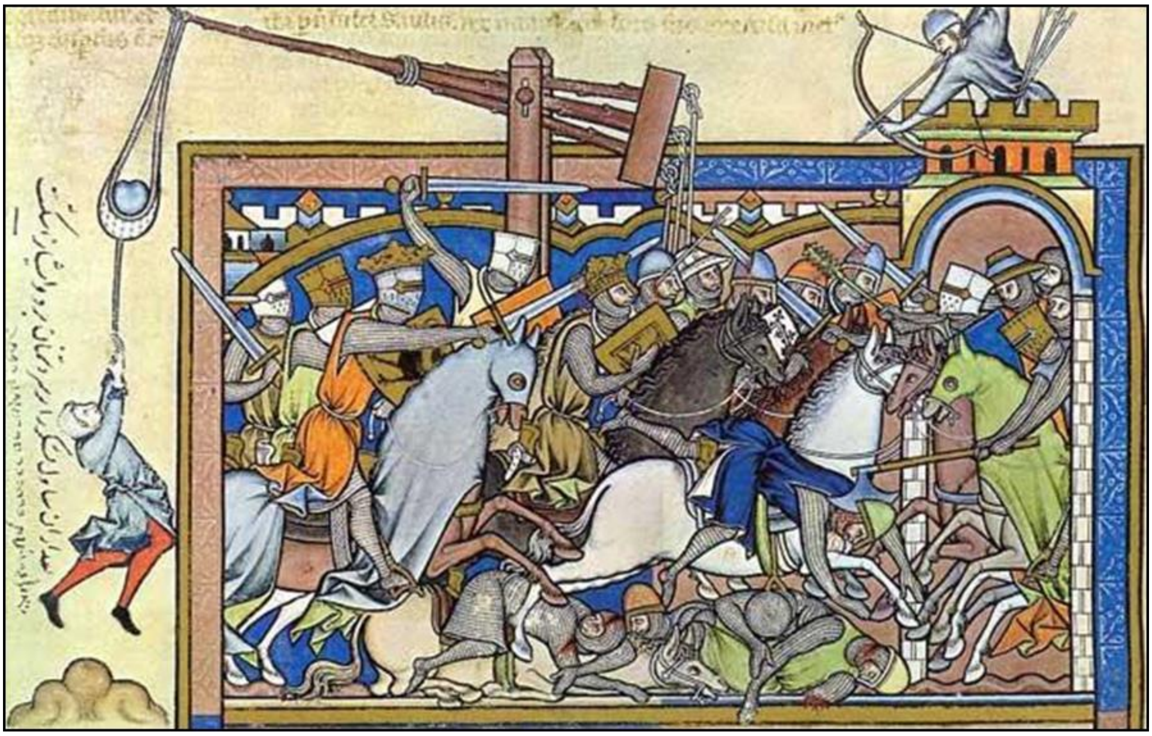

Figure 2: Maciejowski Bible, (1240s), detail of illuminated manuscript depicting multiple siege activities, including use of a traction trebuchet, cavalry assault on a gate and a sortie by the defenders. Note the variety of weapons depicted. Pierpont Morgan Library. Ms M.638, f.23v. Original image: Pierpont Morgan Library. Available [online] at: https://www.themorgan.org/collection/crusader-bible/46 (accessed: 13/08/2019).

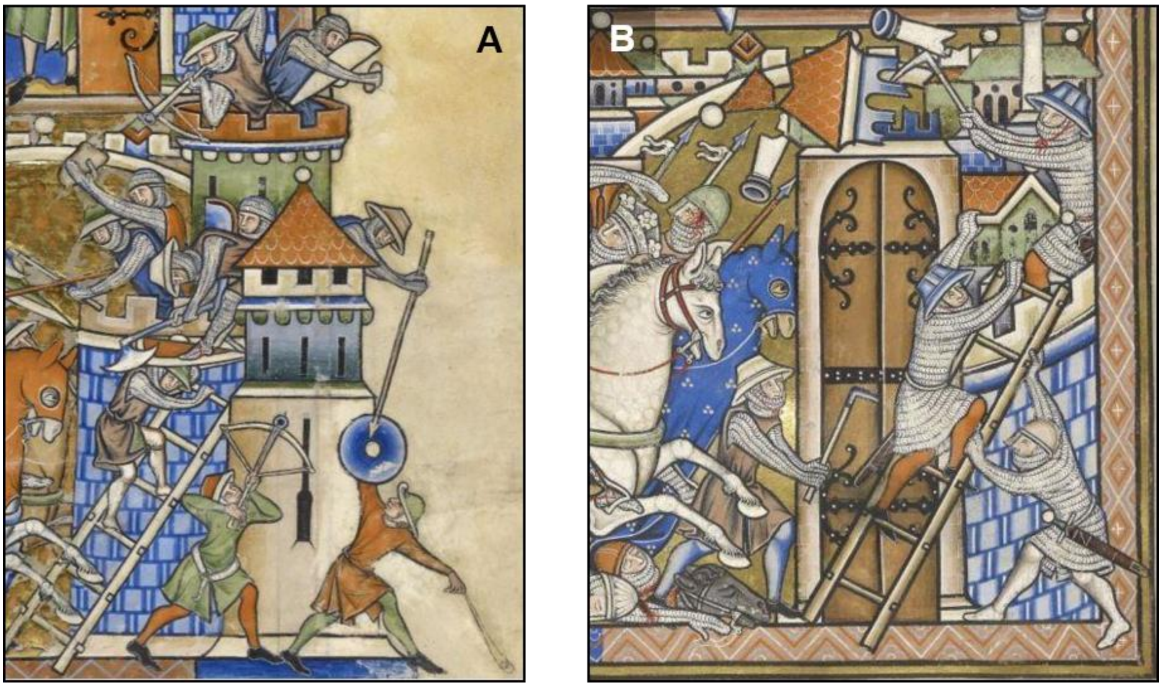

Figure 3: Details from the Maciejowski Bible (1240s), depicting siege activities. Folio 42r (A) depicts a wide variety of weapons used by both besiegers and defenders. Available [online] at: https://www.themorgan.org/collection/crusader-bible/83; Folio 40r (B) depicts destruction of the urban fabric. Available [online] at: https://www.themorgan.org/collection/crusader-bible/79. Pierpont Morgan Library, Ms M638. Original Images: Pierpont Morgan Library.

1.5 Aims and Objectives

The main aim of the research is to investigate aspects of late medieval warfare from the perspective of both the human remains and the historical accounts pertaining to the nature and process of their deposition and taphonomic history. Specifically, it will place the human remains recovered from stratigraphically secure contexts dated to the Crusader period at College Site, Sidon, in both the local and regional context of urban/siege warfare, one of the most significant, yet under-studied themes prevalent throughout Late Medieval warfare; but also within the wider context of Late Medieval warfare in the Frankish States of the Latin East.

1.5.1 Aims

The main aim of the research is to investigate aspects of Late Medieval warfare in the Latin East applying a bioarchaeological approach. It incorporates multiple analyses of human skeletal remains recovered from stratigraphically secure contexts dated to the Crusader period, alongside evidence from both contemporary historical sources and the archaeological context at College Site, Sidon.

The study primarily investigates how patterns of trauma reflect Crusader period warfare and the context in which these assemblages were deposited. Concurrently, the study assesses evidence for the identity(-ies) of the individuals represented by the human remains from burials 101 and 110 at Sidon, through the posing of specific questions regarding their geographic origins, the nature and timing of their deposition and whether the remains can be linked to a specific event or events attested in the contemporary historical sources.

In summary, it places the crusader period human remains recovered at College Site, Sidon, in both the local and regional context of urban/siege warfare, one of the most significant, yet under-studied themes prevalent throughout Late Medieval warfare.

1.5.2 Specific objectives

Each of the objectives below was designed to address both the main aims and one or more of the subsidiary questions concerning the remains recovered from burials 101 and 110 at Sidon:

1. Detailed macroscopic analyses of all remains from burials 101 and 110 incorporating confirmation of the minimum number of individuals (MNI), their demographic profile and assessment of all skeletal evidence for violent physical conflict.

    - The re-association of individuals' remains from burials 101 and 110, College Site, Sidon, Lebanon, incorporating both cranial and postcranial skeletal material using mapped contexts, conjoining of fragmented and trauma-affected elements, age- at-death, and tight-fitting anatomical articulations.
    - The identification and quantification of traumatic lesions on all human skeletal material from burials 101 and 110, College Site, Sidon, Lebanon.
    - Classification and interpretation of all confirmed/definite traumatic lesions from these contexts.
    - Analysis of the distribution of all trauma across the body from these contexts.
    - Refinement of specific questions regarding individual signs of injury (i.e. weapon type, number of assailants, order of injuries, direction of strike, etc.)
    - Digital 3D modelling of confirmed examples of traumatic lesions and pseudo- trauma.
    - Comparison of trauma data from burials 101 and 110 with near contemporary contexts in Sweden, Denmark and the U.K.

2. Confirmation of the initial radiocarbon date (derived from overlying remains) and that both deposits date to the same period.

    - Sampling of individualised articulated skeletal remains for radiocarbon analysis and dating.
    - Refitting of fragmented skeletal remains and identification of definite conjoined fragments from both deposits

3. Characterisation of isotopic signatures for individuals represented within the bone assemblages, incorporating multiple element analyses where possible, in order to address questions regarding the diversity of crusader society, diet, and evidence for migration/mobility at Sidon.
   - Analysis of individualised skeletal remains for strontium and oxygen isotopic signatures
   - Analysis of individualised skeletal remains for carbon and nitrogen isotopic signatures

1.6 Site History

1.6.1 A brief history of Sidon

The city of Sidon has a long history of occupation stretching at least as far back as the Chalcolithic period. It is mentioned numerous times in the Old Testament (e.g. I, Kings 5:6) and is referred to as 'the first born of Canaan'. During the Iron Age, the city rose to prominence, most likely as a result of it being a key supply site of the *Hexaplex trunculus* mollusc (more commonly referred to as *Murex trunculus*) - essential for the production of high-status purple dye. Consequently, Sidon formed one of the main Phoenician city states by the turn of the first millennium B.C. (Bondi, 1997). Despite numerous invasions and associated phases of destruction, particularly under the Assyrians, the city once more flourished during the Persian and Hellenic periods of the Near East, remaining an important trading port throughout the Roman period. Together with Sarafand (ancient Sarepta), just to the south, Sidon also became linked with the origins of glass production. In the aftermath of the major earthquake of 551 CE, the Byzantine-sponsored Beirut School of Law was relocated to Sidon (Collinet, 1925: 57) and less than a century later, the city was conquered by the Arabs in 636 CE. By the beginning of the 12th century (CE), Sidon clearly remained a significant port and under the Fatimid dynasty it resisted the Crusaders for over ten years following the end of the First Crusade.

The town's geographic location and important economic resources have naturally resulted in many of these different empires and peoples leaving a broad range of evidence of their cultures in Sidon and its immediate surroundings (Doumet-Serhal, 2013). This archaeological richness is evident not only at College Site, where there is an almost continuous stratigraphic record representing over 4000 years of occupation, but also at an increasing number of sites throughout the city itself and its hinterland. It is somewhat surprising therefore that the city still retains so great a variety of evidence for the many cultures and periods which have shaped its fortunes and that archaeological investigations have largely been limited to 'rescue' excavations in advance of development, excepting the current research work at College Site.

1.6.2 History of investigation

1.6.2.1 Greater Sidon

The earliest reported archaeological interest in Sidon took the form of a basic survey of ancient monuments in October 1860. The city and its environs constituted one of four key sets of explorative works orchestrated by the French scholar Ernest Renan as part of an archaeological expedition to Lebanon, the results later published together with some Phoenician inscriptions and a map detailing the historical landmarks of Sidon in addition to what were considered the limits of the medieval fortifications, produced by Dr. Gaillardot in the same year (Renan, 1864).

Over twenty-five years later, between March and May 1887, a major discovery of Persian period rock-cut tombs came to light in the foothills surrounding Sidon. These tombs contained a series of Late Persian/Hellenistic sarcophagi, including the famed 'Alexander' sarcophagus (currently housed in the Istanbul Archaeology Museum). Following the initial report by W. Eddy, news of the find reached the head of the Ottoman department of antiquities, Hamdi Beg [Osman Hamdi Bey], who swiftly secured the site, organising the excavation and recovery of the sarcophagi through ingenious digging of a tunnel and construction of a railway and wharf, by which their transport to Constantinople was effected (Jessup, 1910: XXI, 506-507).

Originally established by the Phoenicians, the temple complex of Eshmoun (also known as Bostan-esh-Sheikh) formed another early focus of archaeological interest in the Greater Sidon area. Located approximately three kilometres north-northeast the city of Sidon, on the south bank of the Al-Awali river, it is possible that this is the site at which the Crusaders arrived on the plain of Sidon in 1099 CE and where Albert of Aachen reported "*… on the bank of a fresh-water river. [There] they found very many heaps of stones*" (Book 5, [§40], in Edgington, 2013a: 203). The site was partially excavated first by Théodore Macridi-Bey and W. von Landau at the outset of the 20th century (Macridy, 1902; 1903; Macridy-Bey, 1904) with further work subsequently carried out by M. Dunand between 1924 and 1980 (Dunand, 1926; 1971; Doumet-Serhal, 1999a: 2; Jidéjian, 1999: 25). By the end of the century, the site was once again receiving attention (Stucky, 1998), although to date no artefacts or remains dating to the crusader period have been reported at this site.

1.6.2.2 The city of Sidon

In the urban centre of Sidon itself, more formal archaeological work commenced again in 1914 under Georges Contenau, with excavations concentrated on and around the 13th century castle of St. Louis; the construction of which had developed an earlier fortified site (Qalat Al Muizz) and included the integrated remains of a Roman amphitheatre, itself overlying the ancient Tell of Sidon. Though the initial excavation was curtailed with the outbreak of the First World War, Contenau returned to the castle at Sidon in 1920. Altogether his efforts culminated in the publication of a series of articles focussed on the city and its land castle (Contenau, 1920a; 1920b; 1923) and Sidon's environs (Contenau, 1920c; 1920d; 1924a; 1924b).

Pringle (1995: 89) reports that P. Coupel recorded the remains of the castle of St. Louis in 1939, prior to their removal/destruction during investigations of the classical and Phoenician periods on the site. The results of these subsequent works are briefly summarised in Dunand's annual reports (Dunand, 1939; 1940; 1941), in the last of which he mentions some evidence for a chapel and concluded that the digging of the Frankish fortification ditches had resulted in the loss of any earlier stratigraphy down to the Roman levels. Donceel (1967) mentions some further archaeological work on the site of the Land castle, carried out by H. Kalayan and Msr. Asmar in the mid-1960s; and reports the demolition of the college between 1961 and 1962.

In the 1960s, interest moved beyond the Land Castle. After completing his exploratory excavations at College Site following demolition of the Gerard Institute and the Marist College buildings (both modern educational establishments founded at the turn of the 20th century - see 1.6.2.3), Dunand re-focussed his efforts on an area of approximately 5,000m^2 just northeast of St. Louis' Castle, now known as Sandikli site. Dunand's excavations here resulted in the uncovering of a late antique/early Islamic bath complex. In 1970, a further sounding was carried out inside the castle by the Directorate General of Antiquities (DGA) to test the theory proposed by H. Kalayan that the original medieval fortification incorporated and retained the in situ remains of a classical amphitheatre (Doumet- Serhal, 1999b: 32). Soon after this, Kalayan, evidently, switched his attention to the sea castle, carrying out a building survey of its remains and producing a new interpretation of its construction and development (Kalayan, 1973).

1.6.2.3 College Site, Sidon

College Site takes its name from the two educational institutions established at the location during the late 19th century: the Marist College and the Sidon Academy for boys, a branch of the American Protestant Mission College. The archaeological significance of the site first came to attention towards the end of the 19th century. Between 1884 and 1889, construction of the Academy (later known colloquially as 'The American School') took place on the area along the edge of the old town of Sidon. The discovery of the outstanding antiquities reported in 1887 (see section 1.6.2.1), and the astute archaeological recording and management of the site by the local Ottoman administrator, Hamdi Bey, appears to have encouraged interest in the archaeological evidence of ancient Sidon. Very soon after, in 1888, a basic stratigraphy of the College Site location was published (Dawson, 1888), following the foundation of the Academy. Following this, a double bull protome capital was also discovered during the foundation works for buildings associated with the new school (Contenau, 1923: 276; Asmar, 1997: 2; Doumet-Serhal, 1999b). These finds of marble sculpture were later to lead Clermont-Ganneau, citing Diodorus of Sicily, to suggest they indicated the site of the Persian Apadana or pleasure garden at Sidon (Contenau and Clermont-Ganneau, 1921).

With the focus of archaeological investigation shifting to the nearby land castle in the early 20th century and excavation on the site obviously precluded by the construction of the school buildings, little new evidence appears to have come to light from College Site until the 1960s. Between 1961 and 1963 the Marist college buildings on site were demolished (Doumet-Serhal, 2016: 3). By this time, following an increase in student numbers and changes in its educational requirements, the American School (now re-named: the Gerard Institute for Boys), appears to have outgrown the facilities at College Site. The school having moved to a new location, the remaining College Site buildings were demolished during the same period as those of the Marist college, certainly by 1965, but possibly as early as 1959 (Doumet-Serhal, 1999b: 33).

Demolition of the various college buildings and clearance of the site subsequently permitted Maurice Dunand to carry out a series of exploratory excavations across an area of c. 6,500m² to the north/northeast of St. Louis' castle (Doumet-Serhal, 2004: 89). The general area of these soundings was acquired by the Lebanese Directorate General of Antiquities (DGA) by 1965, following their characterisation as sites of major interest (Doumet-Serhal, 1999a). The main reasoning behind their expropriation by the state appears to have been the earlier discovery of the double protome capital of Persian date, consisting of two bulls, crouching back to back, along with fragments of a shaft and base of a column, originally discovered during the digging of foundation trenches for the construction of the Gerard Institute at the end of the 19th century.

Unfortunately, these early investigations produced only very limited published data. While Contenau did produce several published articles relating to the land castle and the vicinity of College Site (Contenau, 1920a; 1920b; 1923; Contenau and Clermont-Ganneau, 1921), these lacked the standardised practice and protocols which have since developed within modern archaeological investigations. Aside from his annual reports of archaeological works, Dunand produced only a brief summary of his fieldwork in the 1960s (Dunand, 1967) and did not publish his excavations of the Roman bath complex on the Sandikli site.

In 1975, war again prevented any substantial archaeological investigations in Lebanon with the period of the Lebanese civil war lasting until 1990. In the immediate aftermath of the conflict, archaeological resources were heavily focussed on Beirut with the unification and reconstruction of the city the immediate priority. However, in 1998, a core sampling programme was carried out in Sidon and its harbour environs by Dr Claude Doumet-Serhal (Espic et al., 2002; Morhange et al., 2003), with initial excavation soundings also undertaken between 1998 and 2000.

In 2000, following approval by the DGA in 1998 (Curtis, 1999), research excavations commenced under the direction of Dr Doumet-Serhal with support from the British Museum's Department of the Ancient Near East. Archaeological investigation has been on-going with annual research excavations taking place every year since, supported by local and foreign sponsorship. Excavations and associated research have produced an increasingly diverse programme of public engagement and outreach involving local schools, local and foreign undergraduate and graduate students, local and global media, international museums and social media.

In 2014, work commenced on the development of part of College Site for the purposes of a bespoke new museum to house artefacts from the site and present the archaeology. The research excavations have continued alongside targeted rescue excavations (the latter usually involving more rapid, deeper excavation work in limited areas in conjunction with foundation works), forming part of the on-going museum development.

2 BACKGROUND

2.1 Historical Background

The main period of the Crusades in the Near East is generally accepted as commencing from the arrival of the Crusaders in northern Syria in 1098 prior to the siege of Antioch and lasting for almost two hundred years until the Fall of Acre and its immediate aftermath in May 1291. Directly linked to the concept of the Crusades in the Latin East was the foundation and development of the Frankish States in Syria, Palestine and Jordan, incorporated by Bohemund and the other prominent Frankish nobles. These were formally established during the course of the First Crusade and in the following period of expansion and consolidation spanning the first half of the 12th century.

The chronology of the Crusader states can be broadly split into two periods. The first encompasses the expansion and consolidation of the crusader territories during the first half of the 12th century and saw the construction and development of a network of supporting strongholds as well as the foundation of the Military Orders and the increasing involvement of the Italian city states, Venice, Genoa and Pisa. At the same time, the actions of the Crusaders were facilitated by the continuing disunity and internal conflict among the surrounding Muslim states: These included the Zengid dynasty, representing the Sunni Seljuks to the northeast, the Isma'ili Shia Caliphate of the Fatimids based in Egypt to the south and the Sunni Abbasid Caliphate focussed on Damascus, Mosul and Baghdad to the east.

Only when the Muslims began to unify during the second half of the 12th century, initially under Nur ad-Din and then Salah ad-Din (henceforth Saladin), did the Frankish states come under serious threat, with open conflict increasing towards the end of the century, culminating in the Crusaders' disastrous defeat at the battle of Hattin on July 4th 1187, which represents the end of this first period of Frankish occupation.

The second period of the Frankish states, constituting the remaining years of the 12th century and almost the entirety of the following century was characterised on the whole by Christian in-fighting and by a generally defensive attitude. While Saladin had failed to take Tyre, the loss of the majority of crusader possessions in the Kingdom of Jerusalem, as well as other important ports including Tripoli, along with Saladin's destruction of their walls and fortifications meant that the crusader infrastructure had been sorely reduced.

2.2 Crusader Society

2.2.1 Participants

Right from the outset of the First Crusade and throughout their existence, the Crusader states consistently received regular influxes of migrants from all over the Christian and Muslim worlds wishing to visit Jerusalem and/or tour the Holy Land. These migrants included pilgrims, merchants, diplomats, scholars, specialist contractors and mercenaries, as well as those ardent Crusaders intent on action and wishing to actively contribute to the taking back of Jerusalem and the Holy Land, preferably by force of their own arms.

Fulcher of Chartres, an eye-witness to events of the First Crusade, was impressed by the great variety of individuals from different lands taking part in this expedition and the many languages they spoke (Runciman, 2016a: 156). Indeed, a broad variety of individuals and groups from all over western and eastern Christendom are attested. Amongst a great many other groups, the Crusader army included Flemish and Lorrainers as well as the forces of its Norman and Frank leaders (Runciman, 2016a: 157). Following the taking of Nicaea, a contingent of Byzantine troops, led by the experienced general Taticius, accompanied the Crusaders westwards too, acting as guides on their journey across Asia Minor (Runciman, 2016a: 152). The Crusaders were also subsequently aided by Guynemer of Boulogne's pirate navy which included Danes, Frisians and Flemings.

The Crusaders were not simply marching into a world inhabited by Muslims adhering to a single, homogenous faith. The Byzantine empire lay between the West and the Holy Land, along with the Eastern Orthodox Church and both of these authorities harboured interests in Palestine and the wider Southern Levant as well as wishing to re-affirm the eastern borders of the Byzantine empire itself. Initially at least, the Byzantine emperor Alexius I, aided and supported the First Crusade (as evidenced by Taticius' commission mentioned above), but clearly matters became more complex once Antioch, a key Byzantine interest, had been taken and Bohemund declared his principality.

In the north of the Levant, the contemporary historian Matthew of Edessa reports both the Roupenian princes of Armenia as well as Armenian religious communities supported the crusader army during the siege of Antioch, providing food and supplies as famine threatened the forces under Adhemar of Le Puy in the Winter of 1097-98 (Runciman, 2016a: 184). However, the Crusaders' relations with Armenians and other local Christians were not always harmonious. Both Armenian and local Syrian Christians could take advantage where the opportunity arose, charging high prices for provisions (Runciman, 2016a: 184). Even so, Armenians clearly attained significant social positions within the Frankish states in the Latin East as Joinville notes in 1250, when a certain John the Armenian is reported to have been the king's weapon-maker (Joinville [§446], in Smith, 2008: 255). Georgians, too, are a noted presence in the Holy Land, both resident in a religious context (Rothelin Continuation, in Shirley, 1999: 20-21) and on crusade in the early 13th century (Gerbert of Boyx, in Barber and Bate, 2010: [56], 97).

Concerning those involved in fighting, across the broader context of late medieval warfare, most infantrymen were servants of the knights (France, 2000: 53). Yet this was not the whole picture, particularly in the Latin East where the population of the Frankish states was continually debilitated or reduced by warfare, disease and famine. Citing the broadly contemporary record of John of Ibelin (written in 1265), Smail (Ibelin, [pp.426-7], in Smail, 1956: 90-1) reports that military service was due to the king, not only from feudal lords, but also from ecclesiastical and urban communities, with the latter required to provide the middling ranks of the army i.e. sergeants, but only when there was the greatest need. Smail goes on to suggest that these individuals may well have represented only occasional soldiers with limited experience and training, hence only being called upon in emergency.

The make-up of Muslim society, like the Christians was similarly a complicated and fluid mix based on the different branches of Islam, the waxing and waning of political dynasties and empires; as well as a wide variety of tribal or ethnic groups hailing from a range of geographic regions that encompassed Eastern Anatolia, the south Caucasus, Syria, Palestine, North Africa, Egypt, Arabia and the whole of the Middle East.

The Muslim armies throughout the Crusader period were characterised by a broad mix of a wide variety of tribal groups and cultures from all over the Levant, the Middle East and North Africa. As the various dynasties rose and fell, so some of these groups came to the fore or faded from prominence. The armies of the later Fatimid Caliphate included Arabs, both settled and nomadic groups, alongside Berbers, Armenians, Sudanese and Turkish forces (Nicolle, 1979: 164). Kurds also often formed at least an auxiliary constituent of the Muslim armies. By 1171, however, they, together with Turks, formed the bulk of Saladin's troops in the years immediately preceding the establishment of the Ayyubids (Nicolle, 1979: 164). In the years leading up to the battle of Hattin in 1187, Eraclius, Patriarch of Jerusalem describes how the forces threatening Jerusalem, included: *"…Turks, Arabs, Alarabs, Saracens and it is hard to admit, pseudo-Christians,…"* (Barber and Bate, 2010: [39], 73). It is worth noting that Kurds were amongst the prisoners taken by the Franks during the siege of Acre in 1191, with Ibn Al-Athīr implying they formed part of the lower social strata of Muslim society when he states they were released along with "*… army pages, the poor, … and those of no account.*" (Ibn Al-Athīr, [68], in Richards, 2010a: 389).

Certainly, other groups remained a regular part of the Muslim forces. In 1171, Saladin still retained a sizeable contingent of 7,000 Bedouin (Nicolle, 1979: 164), although they subsequently fell from favour, when Saladin discovered they were smuggling food and other supplies to the Franks (Gibb, 1962: 82). In 1249, Ibn Wasil records the Bedouins once again allied with the Sultan's army at the battle of Mansourah (Ibn Wasil, [FO. 357r-v], in Gabrieli (ed.), 1984: 287). These broad groupings of the Muslim forces can be further broken down into tribal groups, with Nicolle (1979: 66-68) providing some details on these (see APPENDIX A1: The Eastern Armies). By the time of the Mamlūk Sultanate (post-1250), the army had become increasingly well-organised. Even so, it was not wholly reliant on the professional Mamlūk warriors themselves but included mobile covering forces of both Turkoman light cavalry and mounted Bedouin Arabs (Nicolle, 1979: 170).

Furthermore, by the mid-12th century, the Christians and Muslims of Western Asia were joined by a new group intent on making its mark. The Mongols, particularly the Ilkhanate horde, made a brief but significant impact on Syria and Palestine, with consequences for both Christian and Muslim policy.

2.2.2 Civilians

It is clear that the initial crusading phenomenon included not only those of fighting age and a military disposition, but rather a cross-section of medieval society. Albert of Aachen gives a broad description of the civilians accompanying the Crusade at the siege of Nicaea:

> *"… there were not a few followers and lesser ranks, servants, maidservants (married and unmarried), men and women of every class. In charge of all of these were bishops, abbots, canons, monks and priests to teach them and keep up their courage."*

(Albert of Aachen, in Edgington, 2013a: 61)

Not long after, at the battle of Dorylaeum on July 1st, 1097, Runciman (2016a, I: 153) notes that non-combatants amongst Bohemond's crusader army were grouped in the centre of the camp around some springs as it came under attack from the Turkish forces, with women carrying water from the springs to supply those at the front line. William of

Tyre describes this group including: "*…aged men and women, a helpless throng…*" (William of Tyre, [Ch.13], in Babcock and Krey, 1943: 170). More contemporary to these events, Albert of Aachen reports how these camp followers were particularly vulnerable during surprise raids and, in this instance, during the rapid attacks of the Turkish cavalry:

> *"… as they ran through the camp some were pierced by arrows, others beheaded by the sword, several taken prisoner…women both married and unmarried were beheaded, along with men and little children… [The Turks] burst into the camp in strength, striking with arrows from their horn bows, killing pilgrim foot soldiers, girls, women, infants and old people, sparing no one on grounds of age."*

(Albert of Aachen, [Ch.39], in Edgington, 2013a: 74-75)

Local residents too could become unexpectedly involved as combat developed. Ibn Al-Athīr refers to an ambush of a crusader cavalry contingent and its subsequent counter-attack along the route between Caesarea and Arsuf:

> *"… they [the Franks] grouped together and the cavalry as one man charged the Muslims who turned their backs in flight with no thought for one another. Many [auxiliary] cavalry and common people had been accustomed to take a position during a battle close to the action. On this particular day they had followed this practice and when the Muslims were routed, a great number of them were killed."*

(Ibn Al-Athīr, [§70] in Richards, 2010a: 390)

Civilians, including pilgrims and merchants, could also be called upon to support or actively participate in warfare, as reported by Ibn Al-Athīr at Raymond of St. Gilles' failed siege of Tripoli in 1103-4 (Ibn Al-Athīr, [X, 225] in Gabrieli, 1984: 17). Sieges and army camps often attracted merchants and tradespeople supplying foot soldiers and knights alike with food, provisions, entertainment (and other ever-present needs) in the event of a protracted military encounter. Stalls in nearby urban centres or the markets of towns and cities under siege appear to have been in high demand in some instances at least (see Joinville, [§170] in Smith, 2008: 187); and localised markets were even organised within encamped armies, as at Sultan al-Malik as -Salih's encampment at Mansourah following his withdrawal from Damietta in June 1249 (Ibn Wasil, [FO. 387r-v], in Gabrieli, 1984: 287). Brothels served the needs of the 'rank and file' according to Joinville who reports that Louis IX dismissed later those men he knew to have organised and run such activities within the Crusader's camp outside Damietta in 1249 (Joinville, [§171] in Smith, 2008: 187).

Such activities are equally likely to have been prevalent during peacetime. Furthermore, the renewal of access to key holy sites with the establishment of the Crusader states is likely to have resulted in the development of great demand for facilities and services to accommodate an expanding population. Pilgrimage and pilgrims clearly became essential to Crusader society, with Smail (1956: 95) noting the regular annual influx of pilgrims to the Holy Land in time for the Easter period. However, there is also the suggestion that pilgrims, like modern tourists, could bring problems as well as benefits. Amalric of Nesle, Patriarch of Jerusalem, appears to bemoan the situation in 1173, writing: *"… a multitude of infirm and poor congregate from all corners of the world in this place.*" (Barber and Bate, 2010: [37], 71). The Islamic writer Usama ibn Munqidh also relates that the attitudes of newcomers to the Holy Land could be less than tolerant, describing how local Templar friends intervened when a newly arrived Christian pilgrim took repeated objection to his praying in the direction of the Qibla (Usama ibn Munqidh, [§99] in Gabrieli, 1984: 79-80; see also Hitti (trans.), 1929: 164).

2.2.3 Ethnicity and culture

Smail (1956: 62) notes that there are two views regarding the nature of population of the Frankish States following their establishment at the end of the First Crusade and at the outset of the 12th century.

1) "*… the Franks adjusted themselves to their Oriental surroundings and took root among the peoples over whom they ruled. The result was a new nation, in which all elements were thoroughly blended, which was in no way artificial, and which had a life of its own.*"

2) "*The other school of thought considers that the basic feature of the organization of the Latin states was the imposition of a numerically small military aristocracy over the mass of the native population. This ruling class exploited the subject peoples economically by means of social arrangements which they found in existence, and which were akin to those they had known in Europe. Otherwise they made little difference to the daily life of the Syrians.*"

Smail is convinced more by evidence in favour of the latter interpretation. However, within crusader society in the Frankish states in the Latin East, some individuals were clearly willing to integrate to at least some degree, taking on aspects of oriental culture and lifestyle. Reynaud of Sidon impressed Saladin enough with both charm and guile that his life was spared in the aftermath of the battle of Hattin (Ibn al-Athīr, [27-28], in Richards, 2010a: 360-361). These attempts to orientalise were appreciated by their local counterparts. Usama ibn Munqidh is specific in his praise of the settled Franks who chose to adapt to local culture, stating:

> *"There are some Franks who have settled in our land and taken to living like Muslims. These are better than those who have just arrived from their homelands, but they are the exception, and cannot be taken as typical."*

(Usama ibn Munqidh [§103-4] in Gabrieli, 1984: 78)

Although some ambiguity remains here as to how far these individuals went; some of those Franks settling in the East evidently took up aspects of eastern culture. Concerning the prevalence of voluntary orientalisation, although Usama appears explicit in his indication that these individuals were few and far between, one would also suggest he was being careful not to induce too much goodwill by emphasising such open-minded Franks were exceptional within the Frankish states. Never-the-less, Usama subsequently provides a second-hand anecdote of how a settled Frankish knight, who having previously hosted Usama's Muslim friend, later came to the merchant friend's rescue when threatened by a mob whilst on business in Antioch (Usama ibn Munqidh, [§103-4] in Gabrieli, 1984: 79).

Friendships, as well as commercial relationships, could and did bloom between Muslims and Christians during times of peace, as evidenced by Usama's reference to his Templar associates in Jerusalem (Usama ibn Munqidh, [§99] in Gabrieli, 1984: 79-80). Nobles often married into the established local elites. This practice continued into the 13th century: King Hethoum of lesser Armenia was father-in-law to Prince Bohemund IV of Antioch (Jackson, 2014: 117) and the Eracles text records that another of Hethoum's daughters, Euphemia, was married to the lord of Sidon, Julian I Grenier, in 1252 ([Ch.2 1250-1254], in Shirley, 1999: 139).

Within crusader society, distinctions appear to have arisen between the settled populations (in particular the later generations of early Crusaders) and relative newcomers. James of Vitry mentions that some local Frankish residents in Acre were known as *Pullani* or *Poulains*. James specifically notes that these individuals had been born in the city and thus presumably *Poulains* was, by the early 13th century, a common term for second and later generation settlers (James of Vitry, in Barber and Bate, 2010: [57], 102). This label may have evolved from the term, '*poleins*' which indicated individuals born and raised in the Latin East, as used by the author of the Chronicle of Ernoul to describe the local nobility and settled Franks who were opposed to King Guy's 'court party' at the time of the battle of Hattin (Halsall, 2011). This tradition of distinguishing orientalised Franks, i.e. those born and bred in the Near East continued into the 13th century. Joinville, whilst resident at Acre with Louis IX in 1250, provides another pseudonym for local residents, stating that: "*The inhabitants of that country are known as 'colts'*" ([§434], in Smith, 2008: 252), the English translation of *Poulains* (Knüsel, pers. comm.); although it is somewhat ambiguous whether this term was specifically for those living in Acre at the time or possibly more likely, it was a contemporary general term for local settled Franks. Clearly, however, distinctions between established settled communities and recent arrivals and/or temporary Crusaders were present throughout the crusader period.

2.2.4 Occupations

Historical accounts provide evidence of the diverse work-force Louis IX organised to take with him during the Seventh Crusade in 1250, with this logistical support including specialists such as engineers and miners as well as those with more prosaic occupations such as carpenters and general labourers (Bradbury, 1994: 200). Many of the activities carried out by the population would no doubt have been in support or preparation for warfare as the Rothelin Continuation describes taking place in advance of a military expedition to Ascalon:

"Then in all the streets and lodgings you would have seen men checking their armour, greasing their hauberks, polishing helmets, sharpening swords and daggers, shoeing horses and fitting horse-armour and covers onto their mounts."

(Rothelin continuation, [Ch22 (1239)], in Shirley, 1999: 41)

These activities imply the necessity and presence of specific activities and industries as well as general crafts which would have required skilled professionals, including weapon smiths and armourers, ironsmiths, carpenters, farriers. The latter groups would also have been essential occupations within day-to-day life. Transport was also a significant aspect of daily life, not only for tactical mobility in times of war, but also for the trade and the general economic lifeblood of the isolated crusader ports and strongholds.

Only hints and glimpses now remain of those other individuals who formed the no doubt diverse populations of the towns, cities and broader landscapes of the crusader states. Clermont-Ganneau (1899: 229) reports the discovery of an inscribed stone in Jerusalem, possibly reading "*coquus*" or cook, with a set of cooking implements depicted above the inscription, (see Figure 4A overleaf). A similar grave marker identified in France is associated with Sidon itself and again appears to indicate the occupation of the deceased (Figure 4B).

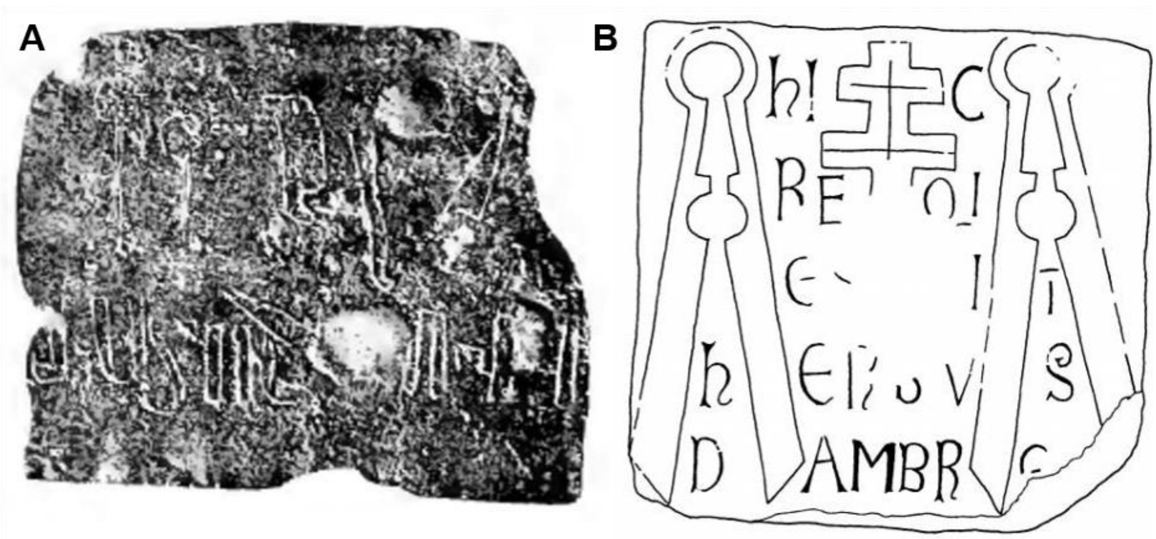

Figure 4: A) Inscription stone described at Jerusalem (Modified after Clermont-Ganneau, 1899: 229, see also Boas, 1999: 25, PL. 2.3); B) Epitaph of Herb(er)t of Ambre[.] from marble slab discovered at Sidon. Lycklama Collection, Cannes. Modified after re-tracing of Clermont-Ganneau (1881, PL. IIc) by Pringle, 2004: 136, fig. 3.

2.2.5 Religion

The conflict between Muslim and Christian control of Jerusalem and its sacred sites, ostensibly the prime cause for the Crusades, necessitated a simplistic narrative between two diametrically-opposed forces. However, this was far from the reality of the Near East. As with the origins and ethnicities of those participating in or impacted by the Crusades, so too were their religions and beliefs a diverse mix of Islamic, Christian and Judaic faiths. Across the Levant, the Islamic faith had split into different branches, with the north largely dominated by Sunni Turks and the south under the auspices of the Shiite Fatimid dynasty, with other smaller derived sects including the Ismailis.

The Christian religion was similarly non-unitary with tensions common within and between the different Christian Churches. In a letter to the Pope in 1098, the nobles leading the First Crusade, having vanquished the Turk Muslims and other pagan communities at Antioch, note they are unable to overcome "*… the Greek, Armenian, Syrian and Jacobite heretics…*", referring to the other Christian churches of the Levant (Barber and Bate, 2010: [8], 32). In their description of Jerusalem, the author of the Rothelin Continuation acknowledges their deliberate omission of all churches and religious institutions not under papal influence at Rome, yet in so doing records the presence of Syrian, Greek, Jacobite, Bedouin, Nestorian, Armenian and other separate religious institutions within the Holy City (Shirley, 1999: 22). The letters of the Patriarchs of the crusader states, such as James of Vitry, also make regular mention of the other Christian sects of the region, including Nestorians, Georgians and Armenians (Barber and Bate, 2010: [57], 102).

It is also worth noting that religion did not necessarily dictate the make-up of either crusader armies or those of their opponents. Ibn Al-Athīr notes that Saladin had placed local Christians in charge of his treasury at the time of the siege of Acre in 1190 (Ibn Al-Athīr, [55], in Richards, 2010a: 380). So, too, could Muslims be employed by Christian garrisons:

> *"A Muslim dwelling in Ḥiṣn al-Akrād [Crac des chevaliers], one of the soldiers of its rulers who in former times surrendered it to the Franks, told me his tale. This individual repented of his former cooperation with the Franks in raiding Islamic lands, his fighting and working [33] with them…"*

(Ibn Al-Athīr, [§32-33], in Richards, 2010a: 364)

2.2.6 Status

From the outset of the First Crusade, it is evident those travelling east and settling in the Crusader states came from all walks of life and every level of society. Ibn Al-Athīr, writing towards the end of the 12th century, provides an anecdote regarding a prisoner:

> *"A certain Frankish captive told me that he was his mother's only son. They possessed no worldly goods other than a house which she sold and used the purchase money to equip him and send him to free [Jerusalem] and that he was taken prisoner. This is an extreme example of the religious and spiritual motivation that the Franks had. They came forth on every variety of mount, by land and by sea, from every nook and cranny. Had God not shown his grace to the Muslims and destroyed the king of the Germans [Frederick I Barbarossa] at his appearance in Syria after he had left home, as we shall recount, people would be saying, 'Syria and Egypt used to belong to the Muslims'."*

(Ibn Al-Athīr, [§33] in Richards, 2010a: 364)

Status, at least in terms of wealth and holdings, was by no means fixed. Conder (1889: 196) highlights that following the battle of Hattin and the loss of Jerusalem in 1187, many of the feudal lords sold their lands and assets to the Military Orders (Templars, Hospitallers, Teutonic knights). However, he notes that much earlier than this, the Church had been benefitting from lands bequeathed by lords at least within the Kingdom of Jerusalem. We know that Julian I Grenier, lord of Sidon, was eventually forced to sell Sidon to the Templars in 1260, having no means to repair its walls and fortifications following the Mongol assault in the same year. He did retain his title but in name only. Conder (1889: 196) also reports that towards the end of the 13th century, "*…nearly the whole of Galilee and the sea coast from Acre to Sidon, and further north.*", was in the possession of either the Teutonic knights or the Venetians.

Slaves were present in both Crusader and Muslim society. Once taken, prisoners if deemed to be of no political value or with little potential for a ransom, were often traded across the wider region or used as cheap labour in construction works (Usama ibn Munqidh, [§100-1] in Gabrieli, 1984: 75).

2.2.7 Impacts of external politics

Following their establishment, the Crusader states, although largely autonomous, were still subject to the interests and intrigues of external powers. Following Bohemond's break with Emperor Alexius I and his founding of the Principality of Antioch, relations between the Crusader states and the Byzantine empire remained fractious in the mid- twelfth century, with both Amalric, king of Jerusalem and Bertrand of Blancfort (Master of the Temple), writing letters informing Louis VII of France of their distrust of the Byzantine emperor and the threat that Antioch might fall into his possession (Barber and Bate, 2010: [26], 56, [27], 57, [31], 61)

Initially external to the Crusader states in the Levant, other conflicts in western Christendom spilled over into the politics of the Latin East. Most eminent of these was the extended dispute between the Papacy and the Holy Roman Emperor, Frederick II of Hohenstaufen. Inevitably, this quarrel resulted in divided loyalties within the crusader states and whilst Frederick did, at least ostensibly, successfully negotiate the Christian repossession of Jerusalem, his methods and subsequent departure sowed distrust and division rather than instilled harmony.

Later in the 13th century, the rivalries between the Italian maritime city states created tensions between their respective communes in the Eastern Mediterranean, especially in Acre during the War of St. Sabas. This extended conflict lasted from 1256 to 1270 and was precipitated by the eviction of the Venetians from Tyre by its lord, Philip of Montfort. The dispute focussed on land inside Acre claimed by both Genoa and Venice. Whilst Genoa gained the upper hand initially, the war went against them when the Pisans switched sides and allied with the Venetians. The Venetians took the land and destroyed the Genoese fortifications there but were unable to dislodge the Genoese forces from their quarter inside the city. The subsequent blockade of the Genoese within Acre itself lasted over a year as they were able to be supplied easily by their allies, the Hospitallers and Tyre (Marshall, 1996: 225). This initial direct conflict developed into an uneasy peace during the 1260s with intermittent naval skirmishes.

During these bouts of low-level fighting, both the Venetians and the Genoese and their respective supporters employed mercenaries, including Muslim soldiers or Turcopoles against each other (Marshall, 1996: 59). The impact on Acre, the capital city and main port of the Second Kingdom of Jerusalem by this time, was highly significant, with the majority of the city's defensive fortifications and towers destroyed or otherwise left in a state of disrepair.

Other internecine conflicts within the Christian ranks included the wars of the Antiochene Succession at the turn of 13th century and the Embriaco conflict which played out in the last quarter century of the Crusader states.

2.2.8 Daily life

In general, the contemporary sources demonstrate that the local population of the Eastern Mediterranean region as a whole was subject to significant hardships during both the Crusader period and that of the Mamlūk Sultanate which overlapped the final years of the Frankish states. In addition to the threats of violence and warfare, the entire region experienced regular natural disasters including drought, famine, disease epidemics and severe earthquakes (Tucker, 1981). The earthquake event of 1202, felt as far afield as Sicily and Mesopotamia and from Anatolia to Egypt, stands out as being of a particularly catastrophic nature. Many coastal cities suffered damage including Tyre, Acre and Nablus, with Tripoli destroyed. Inland regions were also affected, with Baalbec and Homs in Syria severely affected. (Pringle, 1995: 86; Hays, 2013). Hays (2013) reports up to 1.1 million deaths associated with this earthquake alone.

City life in the Crusader states was, as in today's cities, fraught with hazards. In his letter to Louis VII of France, Gilbert of Assailly, Master of the Hospital, refers to petty crime and arson within the walls of Jerusalem, recording that the properties of two lords were burnt down. Gilbert implies the suspects/perpetrators were pilgrims who may or may not have fled back to France but in any event were unable to make good on the damages (Barber and Bate, 2010: [35], 70). Although Gilbert makes no statement concerning whether the fire was deliberate or accidental, it is clear there were sometimes tensions between settled Franks in the crusader states and the pilgrims who were temporarily resident. There is also some evidence for urban centres with burgeoning populations and restricted opportunities for work providing the context in which professional mercenary bands developed (see Marvin, 1998: 250).

2.3 Sidon during the Crusades

Sidon was under crusader control for the majority of the crusader period. Although it only passed into Frankish hands in 1110, it became the seat of one of the most important lordships in the Kingdom of Jerusalem (La Monte, 1944), remaining largely a crusader stronghold until the collapse of the Latin States in 1291; the only exceptions being a five year period following Saladin's successful siege in 1187, a subsequent period of Christian-Muslim condominium between 1192 and 1227 and a brief period under Muslim control in 1249- 50 (Pringle, 1997: 95), although Jackson (1980: 500) also reports that the town was shared between the Franks and al-Nāṣir Yūsuf following Louis IX's departure in 1254 and cites Ibn Shaddād with regard to the Franks having taken control by the time of the Mongol invasion.

Following the disastrous defeat of the Frankish army at Hattin in July 1187, Sidon, along with the majority of remaining crusader possessions in the Kingdom of Jerusalem, fell easily to Saladin. Yet, this was not a bloody siege. Indeed, Ibn Al-Athīr describes how Reynald Grenier, the Frankish lord of Sidon, preferred a tactical withdrawal:

> *"When its* [Sidon's] *ruler heard of his approach, he departed and left it empty of anyone to resist and provide defence. When Saladin arrived, he took it over the very moment of his arrival. It was taken on 21 Jumādā I [29 July]."*

(Ibn Al-Athīr, [§542-543], in Richards, 2010a: 327-328)

There is conflicting information regarding Sidon's control following the period of Saladin's occupation (1187 to 1192) and the signing of the treaty of Jaffa. A period of shared government or condominium is reported for the years between 1192 and 1229. Yet some sources also record that Sidon was once again conquered by Crusaders in 1197 (Piana, 2015: 449). However, during his pilgrimage to the Holy Land in 1212, Wilbrand of Oldenburg describes the situation at Sidon, stating:

> *"… at the present time it is quite the smallest among its contemporary cities, … In fact, it now has few inhabitants, who are ruled – for shame! – by our enemies, who pay certain rents from it to our people in order to keep the peace; for the walls and fortifications of the city have been destroyed."*

(Wilbrand of Oldenburg, in Pringle, 2012: 64)

Only in 1229, during the Sixth Crusade, is there some clarity again with the formal handing over of Sidon and its appurtenances (i.e. local districts) to the Crusaders as part of Frederick II Hohenstaufen's treaty:

> *"…the city of Sidon, too, is given up to us with the whole plain and its appurtenances, which will be the more acceptable to the Christians the more advantageous it has till now appeared to be to the Saracens, especially as there is a good harbor there, and from there great quantities of arms and necessaries might be carried to the city of Damascus' and often from Damascus to Babylon."*

(Letter from Frederick II to Henry III of England, 1229, in Munro, 1902: 25)

This seems somewhat at odds with the records mentioned above, especially as we know that a group of English, French and Spanish Crusaders established the first phase of the sea castle at Sidon during the winter months of 1227/1228 (Eracles Text, in Shirley, 1999; Kalayan, 1973), although there is some indication that these newly arrived Crusaders undertook the work without consent or approval of the local lords.

Sidon again fell to the Muslims during the initial phases of the Seventh Crusade in 1249, following the Crusaders' taking of Damietta. This attack on and surrender of Sidon is likely to have occurred during the summer months of either June or July 1249. Ibn Wasil states a report was received on 24 Rabī' II (August 13th) that the forces of Sultan al-Malik as-Salih in Damascus had attacked Sidon, accepting the Franks' surrender of the town. (Ibn Wasil FO 357r-v in Gabrieli (ed.), 1984: 287). Pringle (1997: 95) reports this period of Muslim control was brief, with Sidon passing back into Frankish hands the following year.

2.3.1 Historically recorded conflict events

Figure 5 provides an overview of Sidon's history during the Crusades. It highlights significant conflict events reported in the contemporary historical sources and also illustrates the periods during which the city was under either Crusader or Muslim control.

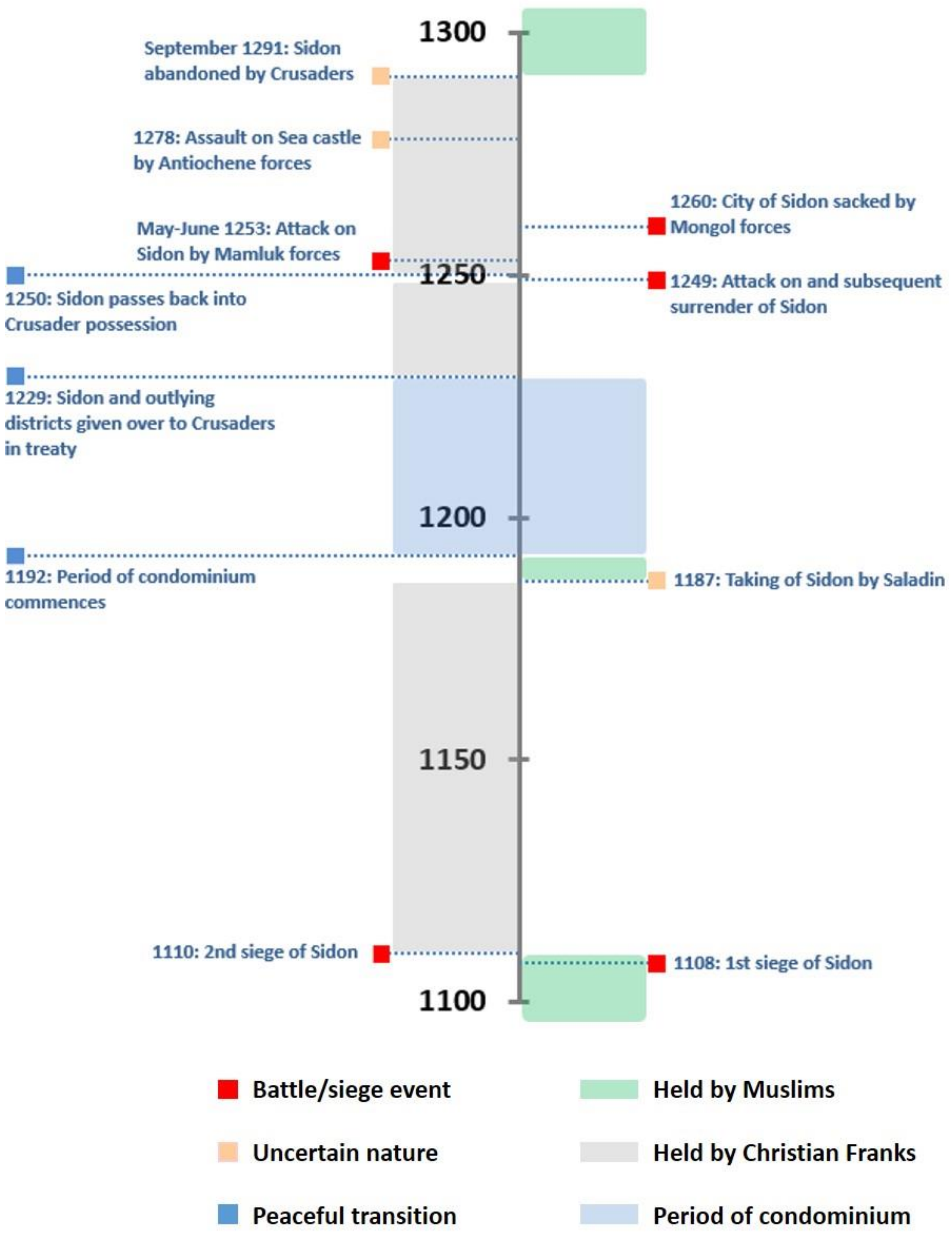

Figure 5: Timeline showing Sidon's history of occupation during the Crusades and the sequence of historically recorded conflict events.

When considering interpretation of the human remains derived from burials 101 and 110, three events in particular are of note. The earliest of these concerns the initial taking of Sidon by the Franks during the siege of 1110, eleven years after the conclusion of the First Crusade. Baldwin I and his forces aided by a newly-arrived Norwegian contingent, took the town after a siege which lasted 47 days. These events are also referred to in the saga of Sigurd I, the king who led the Norwegian Crusaders. The 12th century Norse priest and skald (poet), Einarr Skúlason also provides an account of the siege at Sidon in his saga:

Sætt frá ek dœla dróttin,	*The Norsemen's king, the skalds relate,*
drengr minnisk þess, vinna,	*Has ta'en the heathen town of Saet:*
tóku hvast í hristar	*The slinging engine with dread noise*
hríð valslöngur ríða.	*Gables and roofs with stones destroys.*
Sterkr braut váligt virki	*The town wall totters too, — it falls;*
vals munnlitaðr gunnar,	*The Norsemen mount the blackened walls.*
fögr ruðusk sverð en sigri	*He who stains red the raven's bill*
snjallr bragningr hlaut fagna	*Has won, — the town lies at his will.*

(Einarr Skúlason, 12th century, Heimskiringla/Saga of Sigurd the crusader and his brothers Eystein and Olaf, Sacred-texts.com, 2017)

While the Norse skald's verse confirms the use of siege artillery in the assault of the town, the latter lines, though eloquent, are perhaps the result of some artistic licence, given the town is recorded as having surrendered following terms in order to avoid a final breach and massacre (Albert of Aachen, Bk 11 [31-34] in Edgington, 2013b:169-171; William of Tyre, [Bk 11, Ch. 14], in Babcock and Krey, 1943: 488). Indeed, Phillips reports that the Muslims successfully negotiated to remain on their lands and continue cultivating for the benefit of the Franks (Phillips, 1999: 113). This is broadly supported by Muslim sources such as Yâkût, who records that:

"Ma'dûn (Baldwin?), who was lord of Jerusalem, went against Saidâ with a large army and conquered it, giving the people quarter, but harassing them."

(Yâkût, [vol. 3: 439], in Le Strange, 1890: 347)

The next event of note, for which there is good primary historical evidence, occurred during the Seventh Crusade in 1253, during high summer. John of Joinville (Joinville [§582], in Smith, 2008: 291) records King Louis IX's (later St. Louis) personal involvement in the burial of those inhabitants slain during a raid on the Crusader-held town, which had been undergoing re-fortification. Since his defeat and subsequent imprisonment and ransom following the Battle of al-Mansourah (February 8th – 11th, 1250), Louis had concentrated his efforts on a programme of re-fortification of the remaining Frankish urban centres in Palestine.

In 1253, work had commenced at Sidon under Simon of Montceliard, the Master of the king's crossbowmen, when a large force of Saracens, apparently deterred from assaulting the well-garrisoned city at Acre, proceeded north and attacked the town, which at this point was only partly enclosed by walls. The Saracens reportedly met no resistance, Lord Simon having retreated to the safety of the sea castle along with the few men-at-arms present under his command and those of the residents able to be accommodated within the small isolated harbour castle. Consequently, Joinville reports over 2,000 of those then resident at Sidon were massacred, having been left exposed outside the sea castle (Joinville [§551-552], in Smith, 2008: 282).

The text of the Eracles continuation provides some detail regarding events preceding the attack on Sidon, along with some somewhat more conservative estimates of the numbers of casualties:

"In 1253 Saracens from Damascus appeared outside Acre. They destroyed Doc [Tall Da'uk] and Ricordane [Khirbat Kurdana], took Sidon, killed 800 or more men and carried off 400 or more prisoners, masons and others. The king fortified Sidon once again."

(Eracles Continuation, 12th century, Bk 34, [Ch.2 (1250-1254)], in Shirley, 1999: 139)

Figure 6: Les Grandes chroniques de France, 1332-1350, detail of a miniature of the massacre at Sidon, and Louis burying the dead. © British Library Board, Ms. Royal 16 G VI, f.416v.

Joinville's vivid description of King Louis' hands-on approach upon his eventual arrival at Sidon in the aftermath of the raid, informs us of the state of the remains:

> *"We discovered that the king himself had undertaken to have the bodies of the Christians that the Saracens had killed (as was described earlier) buried. He had personally carried the bodies, all rotting and stinking, to place them in trenches in the ground, and he never once covered his nose, although others did so."*

(Joinville [§582], in Smith, 2008: 291)

In addition, several near contemporary sources provide illuminated depictions of the events reported by Joinville (e.g. Figure 6 and Figure 7).

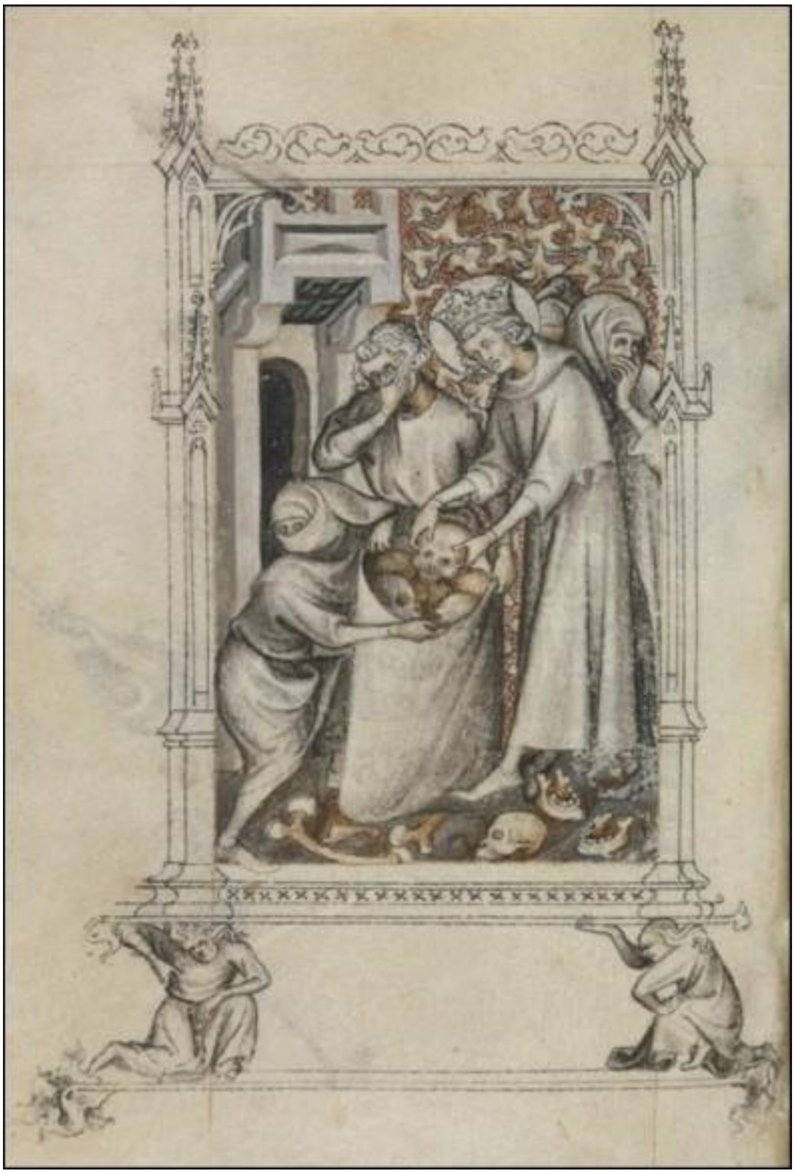

Figure 7: Louis IX helping to collect the remains of Christians, following the raid on Sidon. In Jean Pucelle, *Hours of Jeanne d'Evreux*. 1324-1328. Metropolitan Museum of Art, New York, The Cloisters Collection, Ms. 54.1.2, f.159v. Image provided courtesy of Dr Claude Doumet-Serhal. Original image © Metropolitan Museum of Art, New York.

The third major event for which there is good historical evidence, relates to the sack of Sidon by the Mongols in the summer of 1260. Following the sack of Baghdad in 1258, the advance of the Ilkhanate Mongol invasion under Hülegü, had undermined what little stability there was in the Frankish States and Syria. Whilst Hülegü's successes against the Mamlūks meant that the Franks were no longer the focus of the latter's military efforts, the new arrivals were a comparatively unknown quantity and all the more worrisome given their numbers - no doubt, the aftermath of the siege of Baghdad was still fresh in the Franks' minds.

However, the death of the Great Khan Möngke resulted in Hülegü's unexpected return east with the majority of his forces by the turn of the decade, leaving behind a much-reduced force of between ten and twenty thousand under the command of his general Kitbuqa. Despite this great reduction in the Mongol numbers in Syria, the situation remained tense but stable until in the summer months, Julian I Grenier, the headstrong lord of Sidon tempted fate too far and Kitbuqa launched an all- out assault on Sidon. The broadly contemporary Armenian historiographer, Het'um [Hayton] of Corycus, describes how events appeared to have boiled over:

> *"It happened that some men from Sidon and Belfort gathered together, went to the Saracens' villages and fields, looted them, killed many Saracens and took others into captivity together with a great deal of livestock. A certain nephew of Kit-Bugha, who resided there, taking along but few cavalry, pursued the Christians who had done these things to tell them on his uncle's behalf to leave the booty. But some of the Christians attacked and killed him and some other Tartars."*

(Het'um of Corycus, Fleur des histoires d'Orient, [ch.30], in Bedrosian, 2004)

Whether in retaliation or not, Kitbuqa attacked and sacked the town in mid-August, news of the event reaching Damascus on August 17th (Jackson, 1980: 499). In contrast to the raid of 1253, the town walls seem to have been in good repair at this time, with Louis' works presumably having lasted well up to this point. One could argue this is corroborated to some degree by the description of Julian's steadfast and apparently extended defence of the gate before his eventual retreat to the safety of the land castle which the Mongols were unable to assail. Such was the damage to the town and its fortifications that Julian was subsequently obliged to mortgage the castle along with that of Beaufort to the Templars, being unable to afford repairs and maintenance himself ('Templar of Tyre', [§303], in Crawford, 2003: 35; Jackson, 1980: 499-500).

Despite the destruction inflicted upon the town's fabric, however, the human cost appears to have been comparatively minimal in contrast to similar events. The contemporary author known as [the] 'Templar of Tyre' records that the Mongols, on taking the city, *"…seized a number of common people, killing some and taking others prisoner…*" ([§303], in Crawford, 2003: 35).

From this, one might suggest that the preference was for taking prisoners, 300 of which were led off according to the Arab historian Abū Shāma (cited by Jackson, 1980: 499). ‘Templar’ ([303] in Crawford, 2003: 35) indicates that, as a result of Julian’s defence, the majority of Sidon’s residents were able to take refuge in either the land castle to which Julian himself finally retreated or the sea castle, whilst the fortuitous passing of two Genoese galleys allowed a considerable number of others to be evacuated to an off- shore island close to the harbour, most likely that known today as Ziri, visible to the northwest of the sea castle, in Figure 8 overleaf.

Figure 8: Satellite image showing Sidon and area of College Site excavations (red), with main crusader fortified sites labelled (yellow) (Map source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IG).

In addition to these three key events, there are several other indications of combat in or around Sidon. Wilbrand of Oldenburg makes brief reference to a past skirmish in the area:

> *"Near that city at one time, Leopold the elder, duke of Austria, fought with the enemies of the church and captured and killed those whom he defeated."*

(Wilbrand of Oldenburg, in Pringle, 2012: 64)

It is possible this statement refers to Leopold V of Austria who took part in the Siege of Acre during the Third Crusade, yet there is no mention of Leopold's fighting at Sidon itself and Pringle notes there are no other corroborating sources for such a military encounter near Sidon (Pringle, 2012: 64-65, n22). There is a brief report of an aborted expedition to besiege Sidon in 1189. This expedition was ambushed with fighting: "*… fit to turn an infant grey.*" according to Ibn Al-Athīr, ([§29], in Richards, 2010a: 361), who states the Franks retreated to Tyre, not having reached the vicinity of Sidon; yet Leopold V did not arrive in the Holy Land until Spring 1191 (Pringle, 2012; 64-65, n22). In contrast, it also seems that Sidon may have been on good trading terms at least with the Crusaders at Acre at this time, as Ibn Al-Athir reports that a local emir, Sayf al-Dīn 'Alī ibn Aḥmad, (also known as al-Mashṭūb) brought provisions from Sidon to support them at the siege (Ibn Al-Athir, in Richards, 2010a: 379, [54]).

Alternatively, and perhaps more likely, Wilbrand's account may concern Frederick of Austria who participated in the Crusade of 1197-1198. Leopold VI, a further candidate, did take the cross himself but it was not until the Fifth Crusade (1217-1221), i.e. five years after Wilbrand's writing, that he ventured to the Holy Land. Consequently, one can infer that the skirmish or battle to which Wilbrand's anecdote refers, most likely dates to the Crusade of 1197-1198 and represents a corrupted reference to Frederick, the elder brother of Leopold IV.

Whilst threats from Muslim armies and later in the 13th century, the Mongols, were clearly foremost in the minds of the Frankish settlers, neither was Sidon free from the consequences of internal conflict. The aggressive rivalry between the Templars and the Principality of Antioch in 1278 saw the Sea castle assaulted by sea and Templar prisoners taken in retaliation for an attack by the Order on Tripoli/Antioch ('Templar of Tyre', [400], in Crawford, 2003: 75).

2.4 Weapons

A wide variety of weapons is attested for both western and eastern armed forces throughout the period of the Crusader states, and it is clear many of the weapons common in the west were no less popular in the Latin East. Archers were clearly important both on the field and more especially in siege warfare, both to defend strongholds or to subdue defenders, providing covering fire for other forms of assault (e.g. the construction/movement of siege castles and other equipment, the filling in of dry moats or direct sapping of a town or castle's fortifications). So valued were skilled archers in the period concerned that, following the final storming of the keep during the siege of Bedford Castle in 1224, the remaining archers were spared execution, unlike the knights and others, instead being sent off to Palestine to support the crusader states (Hewitt, 1855: 361).

So, too, archery was an essential part of Muslim warfare, particularly during the 12th century when the Saljuq military traditions were dominant. The Turcoman elements of the Saljuq armies provided skilled mobile horse-archers who could aim and shoot while moving. The more heavily armoured Ghulam forces also carried bows and while limited to firing on horseback from a static position, made up for their lack of rapid mobility by firing handfuls of arrows simultaneously at a rapid rate – up to five arrows in two and a half seconds (Nicolle and McBride, 1986: 9).

Nicolle reports that the majority of the Turkish Saljuq forces of the 12th century were *"… armoured, spear- and sword-armed horsemen fighting in the same Middle Eastern tradition as their Iranian, Kurdish and Arab neighbours.*" (Nicolle and McBride, 1986: 8). Nicolle (1986: 9) also cites the *Warqa wa Gulshah*, an Islamic historical romance, as a source of information regarding weapons of the 12th century, which include javelin, spear, sword, bow, mace and lasso.

Contemporary accounts as well as iconographic sources such as the Maciejowski Bible (see Figure 6 and Figure 7) depict a regular variety of sharp-edged or pointed weapons and heavy blunt objects or a combination of both in use during military actions. Such weapons included swords and daggers of varying lengths and types and a similar range of axes, maces, flails, lances, spears and javelins. Other forms of iconographic evidence, most notably the Baptistère de St Louis (Figure 9 and Figure 10), support the presence of such weapons amongst the Mamlūk elite. Other contemporary objects lend further support for the prominence of war axes amongst the Mamlūks (Figure 11) as well as other weapons and an emphasis on mounted combat (Figure 12).

Figure 9: A) The Baptistère de St Louis, Mamlūk period, attributed to Muhammad ibn al-Zain, 1320-1340, with details of the Mamlūk elite and weapons including lance (B), axes, scabbards and bow (C) depicted. Musée du Louvre, Paris. Modified after original images: Muzeo Collection.

Figure 10: The Baptistère de St Louis, Muhammad ibn al-Zain, 1320-1340, additional detail showing Mamlūk warriors with sabres and maces. Modified after original image: Muzeo Collection.

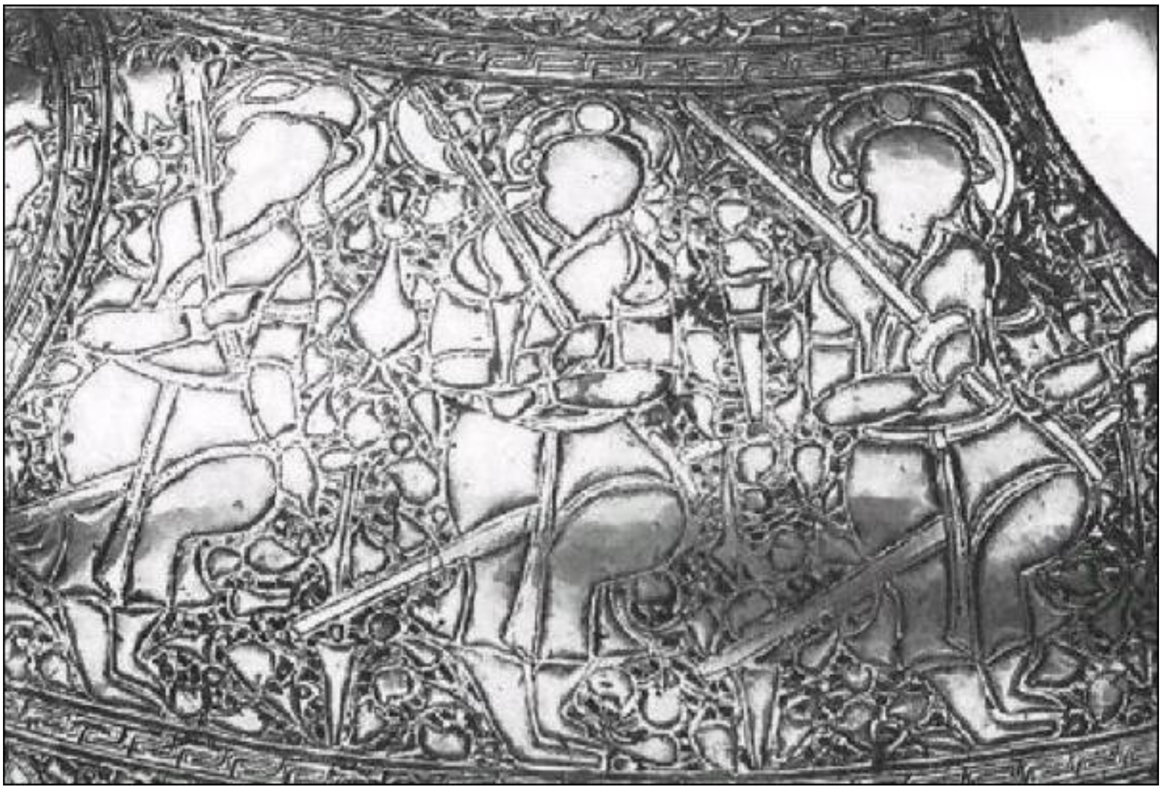

Figure 11: Detail of early 14th century Syrian ewer, showing Mamlūks and prominence of war axes (central and left-hand figures). Modified after Nickel, 1979: 158, fig. 171.

Figure 12: Silver-inlaid flask, Ayyubid period, mid-13th century. Right: detail image, showing mounted lancers and crossbow archers. Freer Gallery of Art, Smithsonian Institution, Washington, D.C.: Purchase — Charles Lang Freer Endowment, F1941.10.

The Rothelin continuation text (see Shirley, 1999) provides numerous descriptions of these weapons, with Saracens' arms regularly including bows, 'Danish axes', maces and swords; whilst those Crusaders noted, most typically knights and other nobles, bore swords and broadswords. Yet from the accounts, it can be also be inferred that both Muslims and Christians used a variety of weapons including maces, lances, swords, axes, cutlasses, clubs and daggers amongst others (see Figure 13-Figure 14 and Figure 15). Weapons could easily be re-used or otherwise swap hands. Usama ibn Munqidh records how Crusaders from Acre pillaged the boat in which his family were being transported, claiming the cargo which included "*… swords and other arms…*" (Usama ibn Munqidh, [§25-6] in Gabrieli, 1984: 75). Specific weapons are therefore unlikely to have been exclusive to one group or another. This was even the case with large weapons or siege engines as Ibn Al-Athīr describes during the siege of Acre in 1190:

> *"Count Henry erected a trebuchet, testudos and ballistas, but the Muslims in Acre made a sortie and seized them, killing many Franks who were by them."*

(Ibn Al-Athīr, [§52], in Richards, 2010a: 378)

Fire, used in a variety of forms, also formed an important aspect in both arsenals throughout the crusader period. It was employed offensively in bombarding and weakening besieged urban centres and other strongholds, yet it was arguably even more important in defence, as a means to destroy or otherwise render inoperable the engines and equipment of the besiegers. Hewitt gives Ibn Al-Athīr's description of the considered use of a form of incendiary substance during the siege of Acre in 1191:

> *"When Acre was besieged by the Christians…there came into the town a man of Damascus, to assist in its defence. He began by casting upon the towers erected by the besiegers, pots filled with naptha and other ingredients. These not being alight, fell harmlessly among the Christians, who laughed at and jeered the Mussulmans for their seeming failure. Meanwhile, the man of Damascus waited till the mixture had diffused itself over every part of the tower. Then, casting forth a lighted missile, in an instant the tower was in flames, and so rapid and so extensive was the combustion, that the Christians had no time to descend: men, arms, all was consumed."*

(Ibn Al-Athīr, tr. M. Reinaud, in Hewitt, 1855: 161)

Hewitt (1855: 328-330) notes that incendiary weapons were used regularly in the Latin East and that they took a wide variety of forms. He refers to the 'Treatise on the art of fighting' by Hassan Alrammah, published in a French mid-19th century publication on 'Greek Fire' (Reinaud and Favé, 1845), which describes how four different methods characterised Arabic use of incendiaries. These included: throwing them by hand; fixing them to staves with which they then attacked enemies; the use of tubular artefacts to pour or direct fire; and projecting burning mixtures of various kinds using a variety of arrows, javelins or lances and other missiles launched by the large siege engines similar to the trebuchets and mangonels of the Crusaders. Reinaud and Favé state the original author died in 1295, with the treatise having likely been written between 1285 and 1295. They also provide some detail on the author's background, noting the prologue that indicates the subject matter was based on the experience of his father and his ancestors as well as other masters of the art (Reinaud and Favé, 1845: 5). Additional detailed descriptions of incendiary devices are provided, including how one lance was designed: "*…so that the spear shall burn the enemy, after having wounded him with its point*". Another type of lance was so contrived that it "*brulera bien et s'étendra à plus de mille coudées*" [will burn well and shatter into [many] shards/needles] (Reinaud and Favé, 1845: 38-39; Hewitt, 1855: 330).

However, it was delivered or implemented, the effects of fire on Crusaders could either be indirect - through the weakening and collapse of walls and gates or siege engines, (leading to a breach and ingress of a besieging force or crushing beneath collapsed structures); or primary destruction of the body as witnessed by the 'Templar of Tyre' in his record of the Muslims' use of Greek fire and its horrific effects during the storming of Acre in 1291:

> *"It happened that one poor English valé was so badly hit by the Greek fire which the Saracens were hurling that his surcoat burst into flames. There was no one to help him, and so his face was burned, and then his whole body, and he burned as if he had been a cauldron of pitch, and he died there. He was on foot when this happened, because his mount had been slain under him."*

('Templar of Tyre', [§498], in Crawford, 2003: 111)

Although weapon technology clearly evolved during the course of the Crusades, this did not necessarily preclude simpler weapons or everyday objects. In modern conflicts there is evidence that random rocks and stones may still be used even where automatic firearms are available (see Simmons, 2002). Any item to hand, especially if it had weight and/or an edge, might be brought to bear as was the case with one sick, captive clerk whom Joinville reports was struck with a stone bowl; although it's not clear whether this or another blow killed the individual in this instance, his body subsequently being thrown in the river (Joinville [§329], in Smith, 2008: 227). Indeed, with this anecdote, it is not difficult to imagine other daily utensils used as weapons and it is even tempting to re-consider the shears on the crusader period funerary marker from Mekhemeh in Jerusalem in a different light (see Figure 4B). Joinville himself describes how he was forced to threaten the Treasurer of the Temple with a convenient hatchet aboard their galley in order to collect money for Louis IX's ransom ([§384], in Smith, 2008: 240).

Unfortunately, extremely few examples of obvious weapons from the crusader period are known today, with the vast majority of late medieval weapon collections deriving from the 14th century or later. Fewer still are those examples recovered from archaeologically excavated deposits which can be securely dated (e.g. Figure 15E). Nicolle and McBride (1986: 9-10) cite examples of a variety of weapons recovered from a probable Fatimid shipwreck dating to the 10th or 11th century (Figure 13), as well as a variety of Levantine sword types dating to the 13th and 14th centuries (Figure 14).

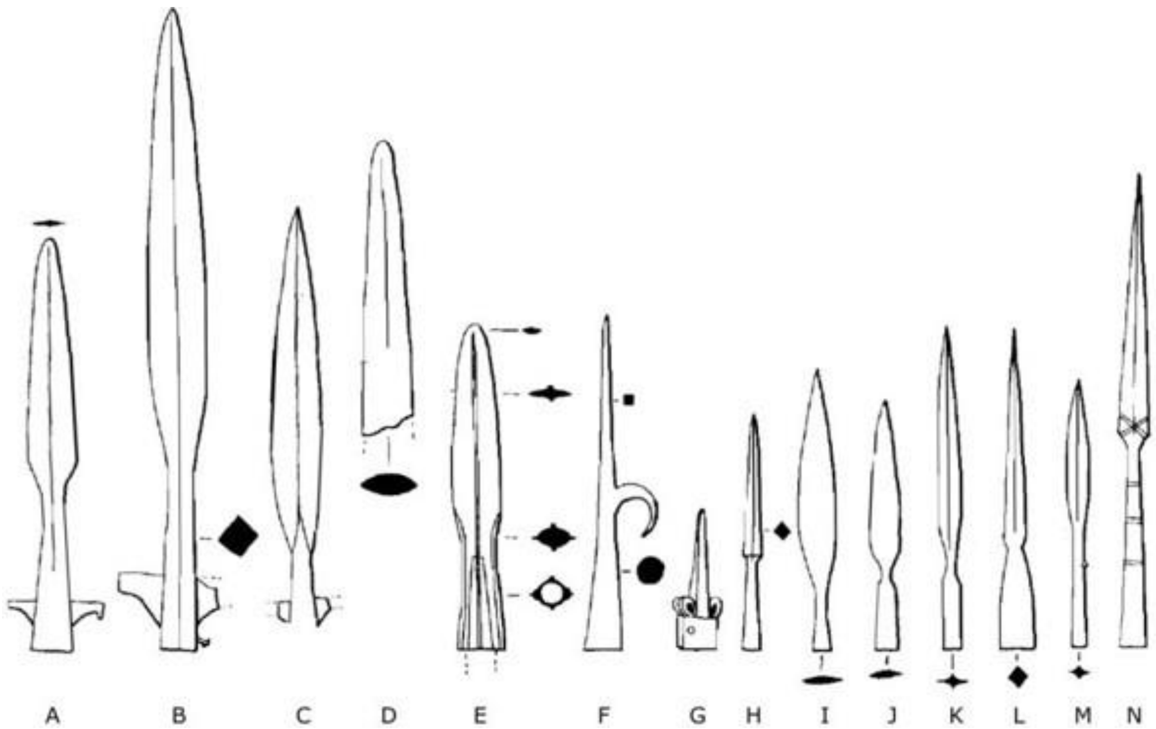

Figure 13: Examples of spear heads. Modified after Nicolle and McBride, 1986: 9. The authors emphasise an absence of arrowheads from this archaeological context, a Fatimid shipwreck.

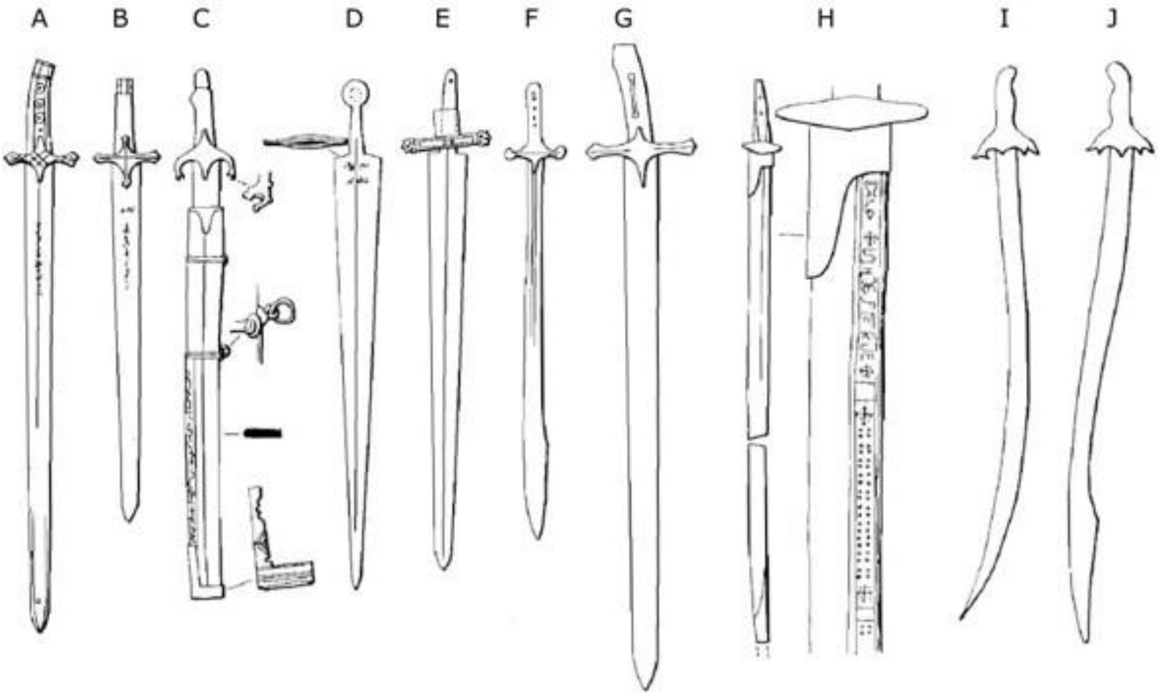

Figure 14: Examples of swords. Modified after Nicolle and McBride, 1986: 10. The authors note that the majority of the swords from Istanbul (A-G) have Mamlūk hilts.

In the wider context of late medieval warfare, France (2000: 53-54) reports little change in the equipment of the common infantry by the first quarter of the 13th century particularly with regards to armour, although he notes the use of other specialist weapons, including hooks and long pikes at the battle of Bouvines (1214). Such weapons were likely also present in Western Asia during the Crusader period.

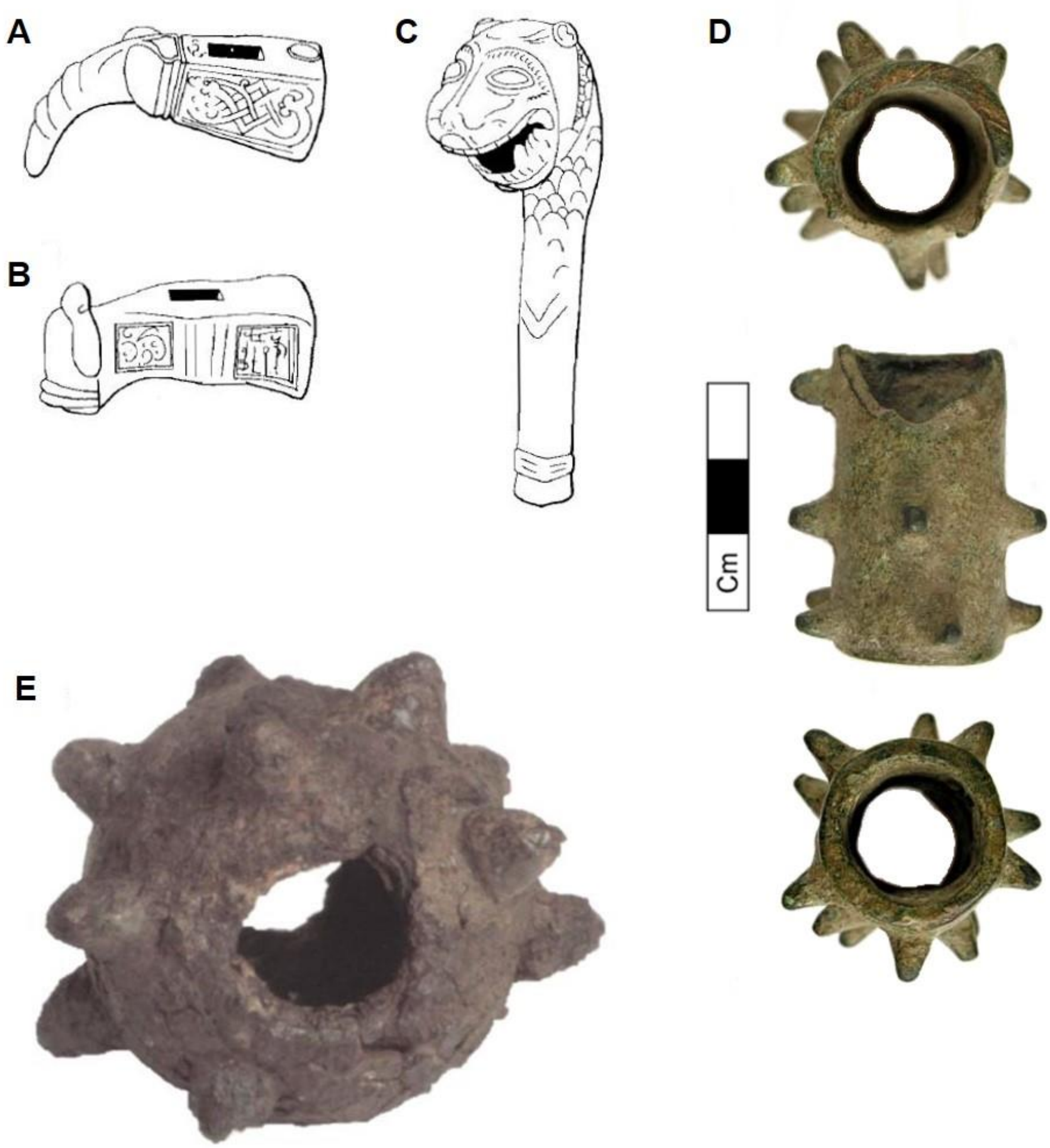

Figure 15: Examples of maceheads and warhammers: A-B) 11th-13th century Iranian bronze war-hammers. Keir Collection, London; C) 12th-13th century Iranian mace-head. Heeramaneck Collection, New York. (A-C modified after Nicolle and McBride, 1986: 10); D) Copper alloy mace head, 1100-1400. Portable Antiquities Scheme, LVPL-E70754 (McIntosh, F., 2008); E) Macehead, 12th century. Diameter: 7.5cm. recovered during archaeological excavations at Vadum Iacob. Israel Antiquities Authority, 1999-1818. Modified after original image: Israel Antiquities Authority.

2.5 Injuries

Throughout the medieval period as in later prehistory, the vast majority of weapons clearly focussed on the application of either a sharp edge or a heavy weight in order to immobilise or kill an opponent or enemy. This was no less the case during the crusades.

In several cases, the historical accounts provide visceral detail regarding the wounds and trauma to which combatants were subject. Whilst battle could be carried out at distance through the use of light and heavy artillery or in relatively short, rapid bursts as with a cavalry charge, with any major engagement either in the field or during a siege, close-quarter or hand-to-hand fighting was generally inevitable at some point. Indeed, Joinville, describing part of the battle of Mansourah in 1250, implies that such fighting was seen to be more honourable:

> *"…And know that it was a very fine feat of arms, for no one fired either a bow or a crossbow, but rather there were blows of maces and swords from the Turks and our men, who were all ensnarled with each other."*

(Joinville [§229], in Smith, 2008: 202)

The effects of archers' arrows and crossbow bolts are not hard to imagine, given the descriptions already provided (see William of Tyre's description, section 1.4). Other weapons too, such as javelins and lances resulted in penetrating trauma. The latter were particularly prevalent in mounted fighting by knights or sergeants/*milites* with horses, as depicted in the contemporary illuminations.

Joinville himself describes his personal experience of a lance in combat, from both ends, though he makes no mention of whether his own actions are honourable or not in this instance:

"… While we were pursuing them through the camp, I saw a Saracen mounting his horse as one of his knights held the bridle. [§221] As he had his two hands on his saddle, ready to mount, I struck him with my lance under his armpits and threw him down dead. When his knight saw this he left his lord and the horse and as I made another pass he thrust his lance between my two shoulders, pinning me down on my horse's neck so hard that I could not draw the sword I had at my belt. I had to draw the sword strapped to my horse, and when the knight saw that I had drawn this sword, he released his lance and left me."

(Joinville, [§220-221], in Smith, 2008: 200)

Fractures are likely to have been common also and are attested in the historical sources. Joinville, in his eye-witness account as an active combatant in the battle of Mansourah, records how having broken through the Turkish ranks on horseback, Count Guy of Forez was brought to the ground by a group of Saracen sergeants. The count had to be carried back by two of his knights, having suffered a broken lower limb, although it is not clear whether this was a result of being brought to the ground or blunt force weapon trauma (Joinville, [§201], in Smith, 2008: 194).

Lower limb fractures are likely to have been an ever-present risk for those involved in mounted fighting. 'Templar of Tyre' describes an incident in the aftermath of the war of St. Sabas where, a reward having been offered by the Prince of Antioch, a group of peasants ambushed Bertrand, lord of Jubail, while he was out riding. 'Templar' reports that on the sudden appearance of the peasants from behind a wall, the lord's horse lost its footing on the uneven ground and fell upon its rider, pinning his thigh. Though the lord kept the peasants at bay with his sword, they consequently resorted to shooting him with arrows, delivering his head to the prince in return for payment ('Templar of Tyre', [§292], in Crawford, 2003: 31). Yet, Julian of Sidon had two horses killed under him, during his spirited defence of the gate at Sidon when the Kitboqa's Mongols assaulted the town, suggesting perhaps a degree in training in how to dismount quickly and avoid being immobilised by one's mount. ('Templar of Tyre', [§303], in Crawford, 2003: 35)

The contemporary illuminated manuscripts indicate some of the effects of these weapons and the wounds they inflicted (see Figure 2 and Figure 3), but it is difficult to assess the veracity of these representations. Some of the personal accounts of contemporary historians go some way towards addressing this gap in our knowledge of the experience of combat. John of Joinville provides an extended and detailed personal account of events during the battle of Mansourah (February 1250), in which he fought with Louis IX's forces. As well as describing the use of siege weapons and Greek fire in the field by the Muslim forces (Joinville, [§203-210, §213] in Smith, 2008: 195-198), Joinville gives some gory details regarding some of the hand-to-hand fighting, particularly in an incident where he and several other knights had been cornered, taking refuge in an abandoned building:

> *"…There the Turks attacked us from every side; a number of them got into the ruined house and stabbed us from above with their lances. … There my lord Hugh of Ecot was wounded by three lance blows in the face, as was my lord Ralph, and my lord Frederick of Louppy by a lance between the shoulders; the wound was so large that blood came from his body as if from the bunghole of a barrel. My lord Erart of Sivry received a sword blow full in the face, so that his nose was hanging down over his lip."*

(Joinville, [§224-225], in Smith, 2008: 201)

Though certainly such accounts hold some part of the truth of such experiences, the physical evidence is still lacking, and these individual accounts are unable to provide the full picture of events involving hundreds or thousands of participants.

2.6 The Osteological Evidence

Only a single report of crusader-period human remains, directly related to a military action and presenting clear evidence of such injuries has been published to date. Mitchell et al. (2006: 148-149) report on five individuals recovered from deposits attributed to the storming of the castle being constructed at Vadum Iacob by Saladin in 1179, observing multiple sword (Figure 16) and arrow wounds, with some arrowheads still *in situ*.

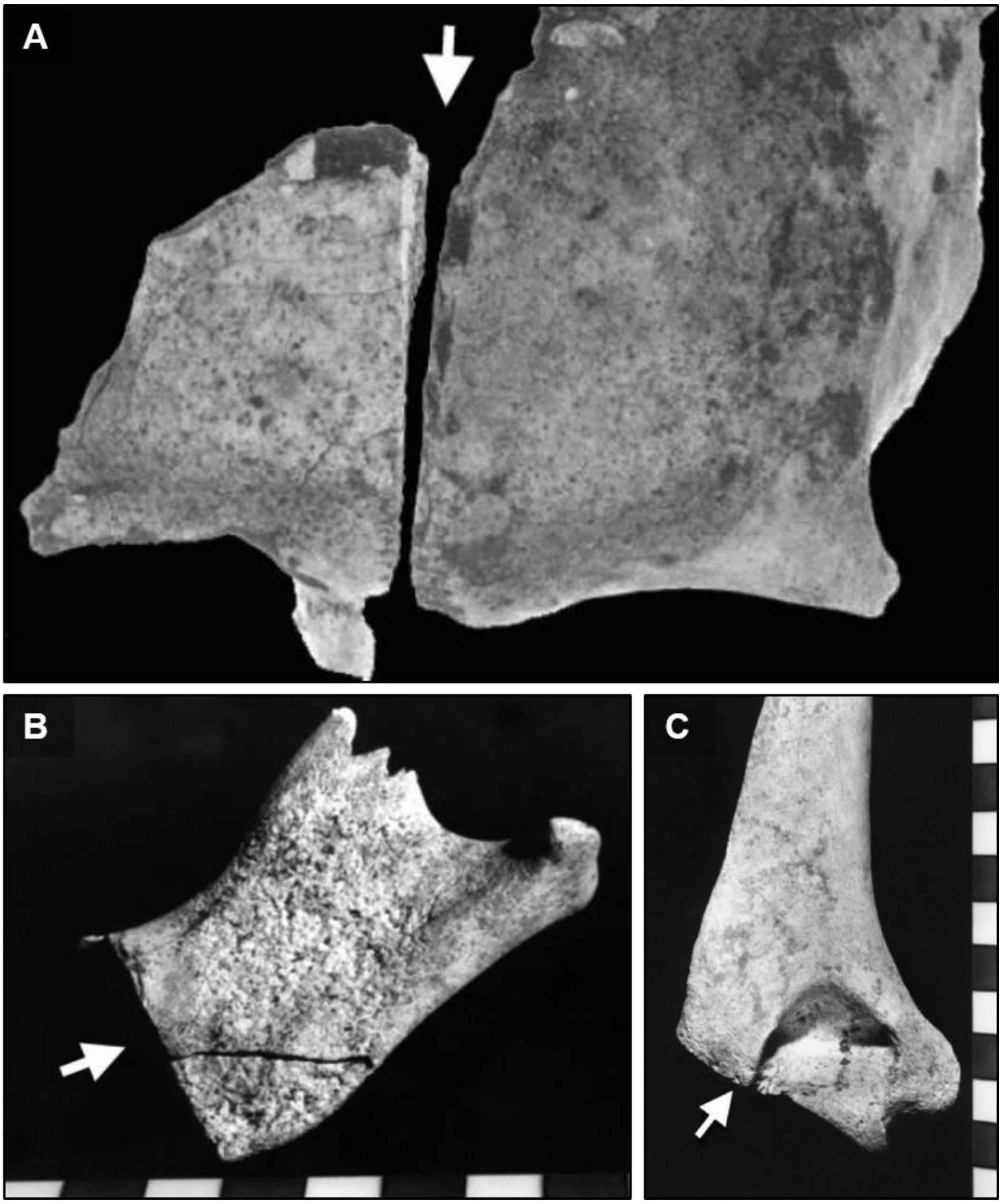

Figure 16: Peri-mortem sharp force trauma in skeleton L929 from Vadum Iacob – A) Anterior cranium with deep cut through midline of frontal; B) Cut from heavy blow to left mandible; C) Oblique cut to distal left humerus, probably resulting in amputation of forearm. Modified after Mitchell et al., 2006: 148-149, figs. 6, 5 and 3 respectively.

Mitchell and colleagues (2006) justifiably attribute these injuries to battle rather than execution, although they acknowledge other possibilities, referring to Walter the Chancellor's account of how Frankish captives were used by the troops of Ilghazi of Aleppo for archery and lance practice in the early years of the Frankish States following the First Crusade (Asbridge and Edgington, 1999: 163).

There is one other instance of potential evidence for a massacre, roughly contemporary with the end of the Crusader States in the Eastern Mediterranean. At Corinth, a context tentatively dated to the early 14th century, contained disarticulated human remains with multiple skeletal elements presenting lesions indicative of peri-mortem sharp force trauma (Williams II et al., 1997; Barnes, 2003; see Figures 17 below and Figure 18). The authors suggest that the dating evidence, along with the presence of peri-mortem trauma in multiple individuals supports an interpretation that these remains may relate to the sacking of Corinth by Catalans in 1312.

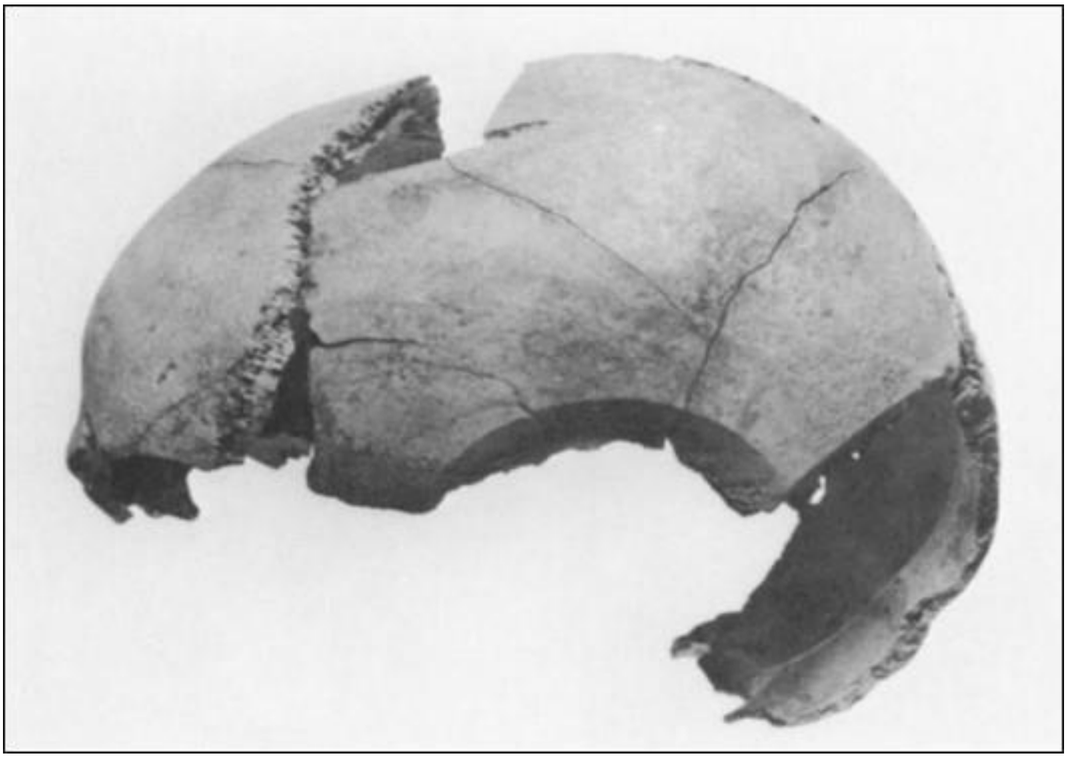

Figure 17: Adult male cranium from Frankish Corinth presenting multiple sharp force trauma, involving left temporal region and posterior left parietal, with radiating fractures emanating from large penetrating, perhaps concentric injury. Original image: Williams II et al., 1997: PL. 11a.

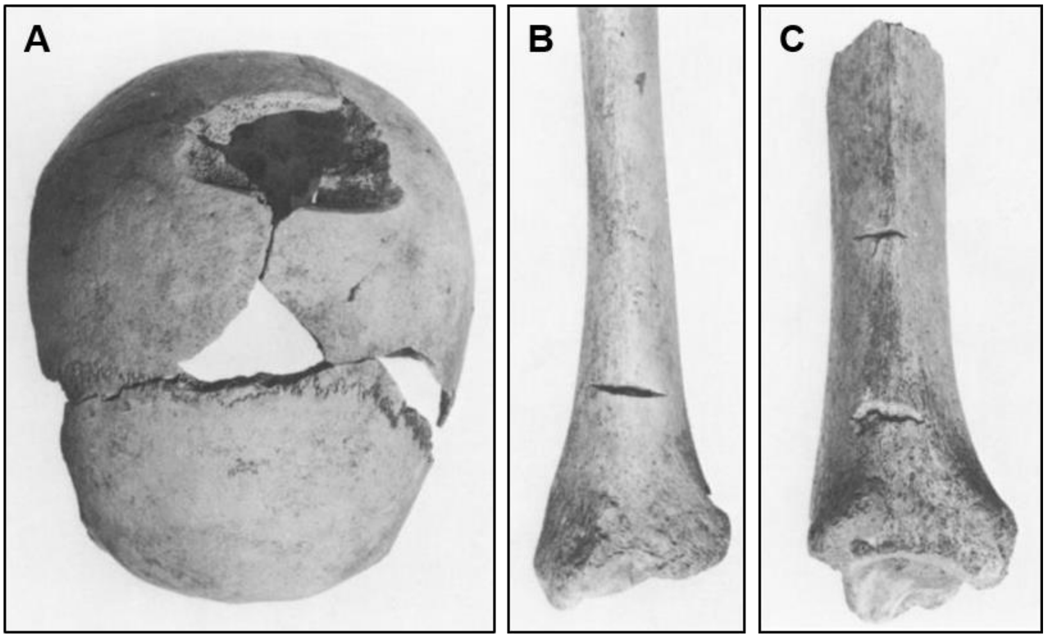

Figure 18: Peri-mortem sharp force trauma from Frankish Corinth – A) Deep cut to superior cranium in mid-sagittal region; B) Single cut to posterior aspect of distal right tibial shaft; C) Two cuts to lateral aspect of distal left tibial shaft. Modified after Williams II et al., 1997: PLs. 11c, 11b and 11d respectively.

Barnes (in Williams II et al., 1997: 30-31) makes particular note of the cut marks on the distal tibiae from two separate individuals (Figures 18B and 18C), suggesting that the blows which resulted in these lesions were deliberately targeted at the Achilles tendon in order to disable the victims. Regarding the context of the remains, however, the disarticulated state of these skeletal elements, found commingled with other disarticulated human remains not presenting any obvious signs of peri-mortem trauma, together with the nature of the context itself (the remains appear to have been sieved from one of the excavated fills of a large, underground water management channel), mean that the connection to the historically recorded Catalan raid is by no means certain.

Although data from other archaeologically-recorded contexts of relevance, (namely cemetery populations dating to the crusader period), are more numerous, they are again rare in comparison to that derived from late medieval cemeteries in Western Europe. By and large, these are limited to the work carried out on the various cemetery contexts from the coastal trading port of Caesarea (Mitchell, 2006b; Mitchell et al., 2006; Mitchell and Millard, 2009), the important Crusader coastal port city of Acre (Mitchell et al., 2008), the rural cemetery from Parvum Gerinum and burial contexts at Tel Jezreel (Mitchell, 1994, 1999, 2006a; Mitchell and Millard, 2009; Mitchell and Millard, 2013), the unusual cave deposition site at Safed (Mitchell, 2004a) in addition to the 13th-14th century Frankish cemetery in Corinth (Barnes, 2003). The crusader period cemetery at ‘Atlit has been the subject of an in-depth study concerning the archaeology of the burial practices (Thompson, 2006), but to date there are no detailed data reported for the human remains themselves.

2.7 Technical Background

2.7.1 Trauma analysis: An introduction

The term 'trauma', as applied within the field of biological anthropology, derives from its usage in modern clinical medicine to denote any injury to living tissue resulting from mechanical force applied extrinsically to a body. Physical trauma has traditionally been used to characterise any injury to living tissue caused by a force or mechanism applied extrinsically to a body (Lovell, 1997: 2008). Trauma and the forces involved in its production, may be either direct or indirect. In cases of the former, the gross changes produced typically manifest at the location of the impact; whilst with the latter, traumatic changes can occur at distance from the site of injury. In recent years, the investigation of skeletal trauma has come to form an increasingly significant and anticipated component of both forensic anthropological and bioarchaeological investigations of human remains (Kroman and Symes, 2012).

The importance of trauma analysis has come about as a result of a number of factors:

- Improved knowledge of the form of fracture patterns, their variability and their relationship to mechanisms of injury
- Improved knowledge of skeletal taphonomy with resultant improvements in distinguishing post-mortem damage from peri-mortem injuries to bone
- Growing involvement of biological anthropologists in the investigation of modern conflict and human rights abuses and concomitant increased need for research
- Renewal of interest in the evolution and the archaeology of violence and warfare and the potential contributions of biological anthropology to debates surrounding this important aspect of human behaviour
- Development of the wider field of biomechanics
- Developments in computer modelling as applied to the human body (e.g. Finite element analysis (Kroman and Symes, 2012))

A principal factor driving this renewed interest in skeletal trauma is the fact that other biological approaches of investigation, such as DNA analyses, cannot address questions which are often key to both forensic and bioarchaeological investigations, including the timing and context of trauma and post-mortem alterations (Steadman, 2008: 227). Furthermore, within bioarchaeology, other forms of evidence for trauma and violence are increasingly reduced with increased time since death and deposition. The further back in time one looks, so the preservation of historical records and weapons becomes rarer due to the exponential impact of any number of taphonomic processes. Thus, human skeletal remains constitute the most direct source of evidence for trauma and violent behaviour spanning the entire timescale of human activity.

Defining when and where trauma occurs can also provide important insights into both the socio-economic context and physical environment in which it takes place. Trauma analysis offers an opportunity to explore and quantify the hazards and risk levels which different populations of humans encountered in a broad variety of social contexts, physical environments and specific time periods in the past. Through greater appreciation of the overall context in which trauma takes place, bioarchaeologists are therefore better able to suggest associations or propose interpretations of global, regional, local or even personal causes and motivations driving societal behaviour. Evidence for violence can vary in its form, quantity and quality, and this is especially true for archaeological contexts (see Knüsel and Smith, 2013b). Progressing further back in time, the evidence for violence is influenced and potentially limited by a number of factors such as population density, level of technological development and state of social development. At the same time particular sources of contextual evidence for violence have their own distinct problems: Fortifications may be built for reasons other than the threat of imminent danger; weapons may simply be symbolic accoutrements rather than offensive objects used in physical conflict; written sources of historical violence are most usually second-hand accounts and often shaped by the personal bias and/or motives of their authors.

Whilst both forensic anthropology and bioarchaeology most often deal with the dead, it is important to note that trauma analysis can also yield insight into the lives of individuals and is not limited to simply supplying evidence relating to their deaths. Antemortem injuries, those accumulating over the course of a person's life and from which an individual recovers and heals, are perhaps even more significant. Such healed wounds constitute evidence of the hazards an individual was subject to, the severity of associated trauma and its survival, as well as the nature and success rate of medical treatment the individual may have received. Such studies have been applied to a broad range of time periods and contexts, including Neanderthals (Berger and Trinkaus, 1995) and early modern England (Brickley and Smith, 2006) in addition to sites and individuals broadly contemporary with the Sidon crusader material (which forms the focus of this study) such as Towton and

Ridgeway Hill, Weymouth (Coughlan and Holst, 2007; Loe et al., 2014; see also Lewis, 2008a).

2.7.2 The Forensic context

Within modern forensic anthropology, trauma analysis has only become accepted practice and an essential facet of forensic case-work in the past twenty to thirty years (Passalacqua and Fenton, 2012: 403; Symes et al., 2012: 341). Symes et al. (2012: 341) suggested that the comparatively recent acknowledgement of the value and potential of trauma analysis can be explained by a number of factors that needed to be addressed first, including:

- The manner in which skeletal remains were traditionally recovered, received and processed
- The knowledge and individual experience of the anthropologist
- The knowledge and individual experience of the forensic pathologist
- The general lack of understanding of bone biomechanics

Symes et al. go on to emphasise that, in earlier years, the lack of communication between crime scene investigators and anthropologists resulted in the latter having no information concerning the context in which remains were found and recovered, a major limitation when attempting to interpret the circumstances in which death and associated injuries took place. Early researchers thus faced significant challenges in differentiating between traumatic injuries and taphonomic alterations.

From the perspective of the forensic practitioner, trauma analysis is predominantly concerned with those injuries directly associated with the manner of death and those peri-mortem injuries or changes associated with the context in which death occurs (Sauer, 1998). Assessment of both the timing and pattern of traumatic lesions is crucial to the presentation and interpretation of evidence in court and can help incriminate, corroborate or exclude/exonerate suspects in the course of explaining events which led to the death of one or more individuals.

Although, it is argued that skeletal evidence can only rarely provide evidence permitting the identification of the (physiological) cause of death (Sauer and Simson, 1984), human skeletal remains can yield evidence relating to the manner of death (Sauer, 1998). Such evidence allows us to categorise death into one of four general categories, with a fifth category represented where the manner of death remains undetermined. The development of human rights investigations has introduced a sixth category, genocide, to the forensic framework, but the specific burden of evidence for this category means it is rarely applicable within standard forensic practice. To date, there have been no explicit reports of interpreted genocide beyond the forensic timescale, although massacres have been interpreted as far back as the early Holocene (Lahr et al., 2016), and their potential to inform on the impact of modern cases of genocide has been highlighted (Fibiger in Carpenter, 2015).

Table 1: Differences in trauma interpretation frameworks between the forensic-related fields and bioarchaeology.

Nature/ Timing of injury	Human Rights/ Forensic Interpretations	Bioarchaeological Interpretation
Perimortem	Genocide	
Perimortem	Homicide	Interpersonal violence
Perimortem	Suicide	
Perimortem	Accident	Accident
Antemortem		Accidental injury
None	Natural	Natural
Not determined	Undetermined	Undetermined

In bioarchaeological investigations, where skeletal remains form the main repository of evidence for trauma, only in extremely rare circumstances do the remains permit an attribution of the mode or mechanism of death. Identification of the cause of death is not generally possible at all, given the usual lack of soft tissues and associated evidence required to ascertain the cause of physiological death (Knüsel and Smith, 2013c: 659). Where manner of death involving trauma is considered, interpretation of the remains alongside information concerning their context is essential. In addition, it is also good practice to provide differential diagnoses allowing for the interpretation of possible alternative explanations (Ortner, 2003).

Consequently, unless several separate lines of evidence corroborate each other (e.g. historical records, trauma patterning, dating, archaeological context), it is very difficult to attribute a single definite interpretation. Hence, where trauma is concerned, bioarchaeologists often limit themselves to reporting evidence for interpersonal violence or accidental injury, rather than attempting to describe or interpret a precise event (Brickley, 2006; Stroud and Kemp, 1993).

It is also worth noting that a significant amount of bioarchaeological research on trauma is most often carried out on attritional cemetery populations. Therefore, not only are such studies limited by the osteological paradox (Wood et al., 1992, see APPENDIX A14: Osteological Terminology Glossary for a brief explanation), but they are also hindered by the nature of such samples that have typically accumulated over a long period of time (possibly hundreds of years) and which represent an accumulation of injuries from any number of different violent and accidental contexts, not necessarily directly attributable to the general population from which the cemetery derives. For example, if individuals died abroad either in wars or as a result of accidental or natural death, their bodies could be transported back to their home territories often a considerable distance away. Alternatively, visiting foreigners may have died as a result of accident locally; refugees may have succumbed to injuries received elsewhere. The burial context itself may also be specific to the individuals associated with it as well as their observable injuries, with cemeteries potentially representing specific groups such as criminals or outcasts (e.g. Reynolds, 1997). In such instances, interpretation of the stratigraphic sequence of archaeological deposits (i.e. burials) can help to determine the nature of a cemetery's use and its development and/or abandonment (temporary or permanent) over time, with diachronic patterning of potential variation in trauma prevalences possible as a result.

In contrast, instances of remains representing multiple individuals deposited in a single event or short space of time, commonly referred to as mass graves, provide rare opportunities to investigate short-term events and circumstances which are often lost to history. Such contexts are highly significant, with important potential for the production of a detailed snapshot of the socio-economic conditions and physical environment from which they derive; they also allow the testing of historical and research narratives and/or the filling in of the bigger picture.

It is only recently that forensic and archaeological researchers have come to truly appreciate the benefits of each other's research foci, the importance of context and the need to move away from examining hard and soft tissues in isolation (Symes et al., 2012: 342; Symes et al., 2002; Smith et al., 2008).

Since the beginning of the 21st century, this on-going research synthesis has led to more detailed scrutiny and further refinement of methods of trauma analysis, especially with regard to tool-mark analysis. Studies have demonstrated potential for differentiating between sharp-force weapon classes (Alunni-Perret et al., 2005; 2010), knife blade characteristics (Bartelink et al., 2001; Shaw et al., 2011), microtraces (Vermeij et al., 2012), blunt-force object characteristics (Delannoy et al., 2012) as well as the use of virtual and simulated tool-mark characteristic modelling (Baiker et al., 2016).

2.7.3 Bioarchaeology

Anthropologists studying past populations have typically considered trauma within either the broader population-level context, usually limited to a specific geographic site or region and/or time period; or more occasionally at the individual level (Appleby et al., 2015; Knüsel et al., 2010). Bioarchaeologists have long been interested in the social context of violent trauma in past societies. As already mentioned, bioarchaeological studies of trauma in ancient remains are made difficult by factors limiting the manifestation of trauma within past societies such as the level of technological development, social structure and available resources. Compounding these issues, environmental and taphonomic conditions influencing the preservation of remains may further reduce or prejudice the evidence for peri-mortem and antemortem trauma.

Within archaeology, the study of trauma has traditionally formed part of investigations into palaeopathology and analyses have consequently followed those methods preferentially applied for the reporting of pathological conditions. This has led to a reliance on basic counts and the calculation of frequencies or prevalence rates for individual sample sets as well as broader population groupings, for example by geographic region or chronological period (see Roberts and Cox, 2003; Roberts and Manchester, 2010; Ingelmark, 1939; Kjellström, 2005; Murphy et al., 2010).

The use and comparison of fracture prevalence rates in both ancient and modern populations have been shown to demonstrate evidence for intentional violence and accidental injury, showing distinct differences between ancient and modern population samples (e.g. Judd, 2004). Studies of trauma in earlier human populations have been limited, most likely due to the comparative scarcity of skeletal material preserved in and subsequently recovered from deposits dating to such early periods (Roberts and Manchester, 2010: 95).

Anthropological research in the field of trauma analysis has broadly aligned along three main avenues of methodological investigation, spanning both archaeological and forensic contexts:

1) Methods for assessment of skeletal evidence of peri-mortem trauma

2) Comparison with known case studies (and/or clinical and forensic data)

3) Experimental studies investigating factors relating to the production and alteration of peri-mortem trauma

2.8 Methods of Assessment

Trauma analysis focusses on assessing bony lesions based mainly on their physical characteristics, with lesions subsequently categorised using several sets of criteria relating to the type of trauma (e.g. sharp vs blunt), whether the trauma impacted the bone directly or indirectly, the social context of its occurrence (accidental vs intentional) and the relative severity of the trauma (fractures vs dislocations). The combination of these categories may vary, but general trends and associations are present allowing interpretations of the mechanism(s) of injury and the context in which they are produced.

For the purposes of this study, dislocations are excluded from the analysis. The reasons for this pertain mainly to the difficulty of their identification in skeletonised materials. Under normal circumstances this is problematic; with incomplete, highly fragmented and commingled remains, it is beyond the current scope of this research. In addition, where confident identification is possible, dislocations typically represent injuries occurring significantly before death with the bone having had time to react and remodel and therefore can only provide some basic contextual information pertaining to the peri-mortem time period.

Originally limited to visual examination of human remains with recording of simple macroscopic observations, the first of these approaches has evolved with the introduction and application of new and emerging technologies. A wide range of techniques are now available including histological examination (microscopy), photography, radiographic examination (including computed tomography and magnetic resonance imaging), digital 3D reconstruction to the computer modelling of bone fracture propagation.

Table 2: Summary of different analytical method categories currently applied to human remains and trauma analysis.

Analytical method	References
Macroscopic	Sauer, 1998; Croft and Ferllini, 2007; Moraitis et al., 2008
Microscopic (inc. SEM)	Alunni-Perret et al., 2005; 2010; Boucherie et al., 2017; Bello and Soligo, 2008; Cerutti et al., 2014; Gilbert and Richards, 2000; Tucker et al., 2001
Radiographic	Ampanozi et al., 2010; Wozniak et al., 2012
Virtual Reconstruction	Fleming-Farrell et al., 2013; Vazzana et al., 2018; Wozniak et al., 2012
Computer modelling	Kroman and Symes, 2012

2.8.1 Known case comparisons and actualistic studies

The use of case studies to document patterns of normal and unusual trauma lesions and patterns has long been accepted in the forensic arena as a way to document and share the types of lesions produced by a wide variety of tools and weapons. Clinical evidence, too, has been used to document the modern prevalence of specific weapon traumata, where it is a salient point that injuries inflicted with hand held implements may be essentially no different from trauma types noted amongst ancient or Medieval remains (Omoke and Madubueze, 2010; Ferllini, 2013). Forensic case studies have also highlighted problems impacting trauma studies, particularly regarding the widely varying effects of taphonomic conditions (e.g. Symes et al., 2012; Ubelaker and Adams, 1995).

Within the archaeological field, case studies are important as they have highlighted the need for careful consideration of cultural context. Some authors have focussed on the identification of evidence for specific weapons or weapon-types (Mcdonald et al., 2007; Lewis, 2008b; Redfern, 2009; Fujita, 2013) or specific fracture types (Dabbs and Zabecki, 2015). Other archaeological case studies have been limited to the assessment of peri-mortem trauma patterns in lone individuals (Brothwell, 1971; Schutkowski et al., 1996; Appleby et al., 2015; Forsom et al., 2017); peri-mortem trauma patterns in groups/grouped material (Fernández et al., 2015; Kanz and Großschmidt, 2006; Nagaoka, 2012;); the effects of taphonomic conditions (Symes et al., 2002; Alunni et al., 2014).

There have been increasing attempts to interpret the evidence for interpersonal violence and warfare in the archaeological record, highlighting how skeletal evidence of trauma can be used to address questions concerning the victims and perpetrators as well as the broader social context and the problems of interpretation (Walker, 1997; 2001; Klaus, 2012). Indeed, research in this area has accelerated rapidly in recent years with a number of edited volumes covering a range of geographic locations and biocultural contexts (Martin and Frayer, 1997; Parker Pearson and Thorpe, 2005; Nichols and Crown, 2008; Martin et al., 2012; Schulting and Fibiger, 2012b; Knüsel and Smith, 2013b; Smith, M. J., 2017; Dolfini et al., 2018) and permitting a broader review of the evidence for violence in the past.

2.8.2 Experimental research

Experimental studies, representing a broad spectrum of research foci, have been undertaken by both forensic and archaeological researchers. Within forensic science, such studies have tended to concentrate on three main areas. These include the identification and characterisation of specific types of trauma and the weapons/tools/objects which produce them (Tucker et al., 2001; Alunni-Perret et al., 2005; 2010; Croft and Ferllini, 2007; Baiker et al., 2016).

The second main experimental research area concerns the investigation of the effects of taphonomic processes on the rate of decomposition and preservation of remains. Some researchers have attempted more general investigations of the effects of local environment (Bell et al., 1996; Campobasso et al., 2001; Calce and Rogers, 2007; Karr and Outram, 2012; Pokines et al., 2018), while other studies have explored specific taphonomic phenomena such as trampling (Olsen and Shipman, 1988) or animal and bird scavenging (Willey and Snyder, 1989; Berryman, 2002; Klippel and Synstelien, 2007; Reeves, 2009).

A major focus, particularly within forensic research, has seen an increasing number of experiments into the effects of fire and heat alteration (Bohnert et al., 1998; de Gruchy and Rogers, 2002; Pope and Smith, 2004; Gruenthal et al., 2012; Ellingham et al., 2015; Ellingham et al., 2016; Macoceviuc and Marquez-Grant, 2017, Waltenberger and Schutkowski 2017).

A third experimental research theme, and that which has been driven by forensic practitioners' requirements, is that of investigation of the post-mortem interval. These studies have traditionally been focussed on identifying as narrow a window for the precise time of death as possible (e.g. Bell et al., 1996). Although not directly relevant/practicable to archaeologists, there is increasing overlap of interest, as the variable time period between death and archaeological recovery is clearly related to the effects of taphonomy.

Archaeologists rarely have the opportunity to identify a precise date of death (let alone specific time), given the timescales involved and the highly variable preservation of human remains. Yet, this is not to say they are uninterested in this information if circumstances and evidence allow (e.g. the case of the remains identified as belonging to Richard III (Appleby et al., 2015; Buckley et al., 2013)). Of more immediate use have been those studies which have highlighted problems or limitations concerning the preservation and subsequent identification of peri-mortem trauma (e.g. Wheatley, 2008; Wieberg and Westcott, 2008; Moraitis et al., 2008; Jordana et al., 2013)

The principles of taphonomy originated within a geological research context (Efremov, 1940) with subsequent experimental approaches to understanding the processes of skeletal decomposition and the impacts of taphonomic processes taking place within the field of ecology during the later 20th century (Behrensmeyer, 1978; Haynes, 1983; Cutler et al., 1999; Faith and Behrensmeyer, 2006).

This research has led to improved knowledge of the factors affecting decomposition and skeletal preservation in a variety of different environments, as well as raising awareness of the issue of equifinality. Understanding where, how and under what conditions, these taphonomic processes may impact or otherwise be confused with skeletal injuries is essential to correct identification of trauma, interpretation of the injury mechanism, the timing of injury and interpretation of the context in which remains were deposited and subsequently preserved.

2.9 Summary of State of Research

An increasing number of mass grave sites and complex group burial deposits are coming to light across the global landscape and spanning the forensic, historic and prehistoric timeframes (see Figure 19).

Figure 19: Map of mass grave sites reported across the archaeological and forensic literature. N.B. This distribution is not exhaustive and is designed merely to demonstrate the large number of such contexts currently known.

Archaeological recording and recovery of these often-complex deposits are essential to improve our knowledge and allow greater understanding of where and when intergroup violence occurs, the context in which it takes place and the correct interpretation of trauma. A multidisciplinary approach incorporating in-depth trauma analysis can provide potential insights into not only the victims, but also their assailants (if indeed there are any) and those involved in burying the dead or otherwise responsible for their long-term funerary curation.

There are current foci on toolmark analysis and taphonomic effects within both the forensic and the archaeological research fields (e.g. Baiker et al., 2016; Kooi and Fairgrieve, 2013; Maté-González et al., 2015; 2018; Pokines et al., 2018; Shaw et al., 2011; Waltenberger and Schutkowski, 2017). Forensic pathology continues to provide physiological context through interpretation of the soft tissue injuries occurring in parallel with skeletal trauma. Clinical medical literature has made substantial contributions to our knowledge concerning how and where it is produced and most particularly its treatment, including the medical management of both accidental and violent injuries and their associated complications.

Yet, obstacles and gaps remain, especially from the bioarchaeological perspective. This is particularly the case for the Late Medieval period, where the limitations of trauma analyses of archaeological assemblages are compounded by a distinct scarcity, not only of the human remains from conflict-related mass grave contexts (Curry and Foard, 2016), but also direct evidence for the weapons causing trauma as demonstrated by the severe lack of well-preserved and well-provenanced weapons from the crusader period (Boas, 1999; Nicolle, 1982: 3-6).

Lack of comparability between studies has started to be addressed in forensic taphonomic studies – but archaeologists are still reliant on case studies that are usually limited by the quantity and precision of contextual data available. For example, a key problem, relevant to both bioarchaeologists and forensic practitioners is that concerning the identification and classification of 'late primary'/secondary contexts, where remains may be moved or transferred in the peri-mortem period following death.

2.9.1 Key principles and problems

The identification of peri-mortem blunt force trauma remains a highly contentious area, with many authors simply reporting data without committing to interpretation or providing differential diagnoses and others deciding not to report data without confirmation of its peri-mortem nature (e.g. where blunt force injuries are overlain by other injuries - see Baraybar and Gasior, 2006: 104).

Commingled remains and secondary mass graves introduce more problems and greater complexity. Partial sets of remains limit observations of trauma patterning across the body; estimation of the minimum number of individuals becomes less certain and traumatic lesions themselves may be altered, obscured or lost completely subject to taphonomic processes up to the time of their recovery and analyses. Despite these obstacles, these complex contexts still represent important caches in which a great deal of information (e.g. regarding manner of death, depositional history, patterns of trauma and the weapons responsible) may yet reside. As such, they hold significant research potential, especially in research contexts where scarce evidence has hitherto been reported (such as late medieval battles and specifically crusader warfare in the Levant).

2.9.1.1 Biomechanics

To more fully understand the nature of skeletal trauma and facilitate its critical analysis, an appreciation of the biomechanical properties of human bone is essential. Fractures occur when a force or forces is/are applied to a bone, placing the stress on the bone and causing it to first strain against this force(s) until either the force (and therefore stress) is removed or until the force exceeds the bone's ability to strain (i.e. resist) it and fails. Stress in bone is typically produced through the application of one or more of a range of different forces. Ortner (2003: 120) provides a clear summary of the forces most commonly involved in bone fracture (see Figure 20).

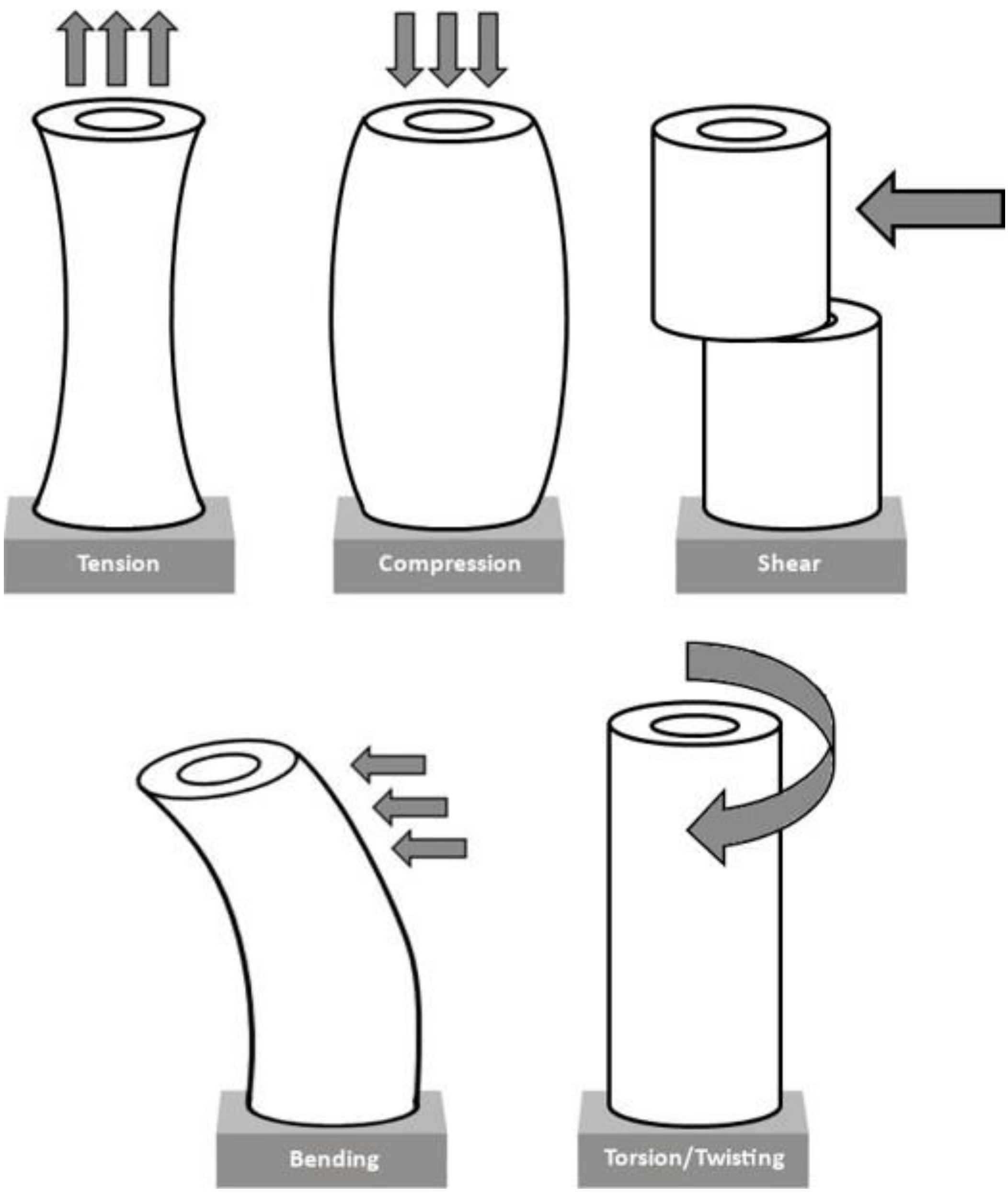

Figure 20: Types of stress resulting in bone fracture. Redrawn after Ortner: 2003: 120, fig. 8-1.

Key to interpreting the causes and processes of bone fracture is understanding how bone behaves as a material under differing conditions. Bone becomes harder and stiffer as it dries out and loses its water component. At the same time, brittleness increases as a result of tensile strain reduction, with differential fracture characteristics resulting (Evans, 1973). These changes to the microstructure of the bone also produce different responses to specific, loading such as compression. A key process in this ‘drying’ out of bone, is the degradation and loss of its organic component, most specifically bone collagen. This organic content constitutes 35% of living bone (Pearson and Lieberman, 2004: 66). This organic protein component provides bone with its elastic properties and with its loss, so bone inherently becomes stiffer and less flexible.

The flexibility allowed for by bone collagen permits both an elastic phase of deformation (from which the bone can recover its original form once the load is removed) and a plastic phase of deformation (where the load exceeds the threshold of the bone, leaving the bone deformed, even after the load is removed). This process of varying flexibility, followed by permanent plastic deformation and eventually complete failure of a material, in this case bone, can be described by two separate concepts: Young’s Modulus of elasticity, and stress-strain curves (Symes et al., 2014). The former relates to the stiffness of bone, while the latter demonstrates plastic strain and ultimate failure and bone fracture (see Figure 21 overleaf).

It is emphasised that all strain modes, whether the bone is under tension, compression, shear or a combination of some or all of these, act simultaneously to produce a fracture (Kimmerle and Baraybar, 2008a; Kieser et al., 2012; Kroman and Symes, 2012; Symes et al., 2014: 344). The resulting individual fracture morphology and patterning of multiple fractures reflect these changing strains and their complex interaction in response to corresponding forces (stresses), which themselves can be loaded at variable rates and in different manners (Symes et al., 2012: 344; Thornton and Cashman, 1986). As Özkaya et al. (2017) note:

> *“The extent of the shape change [bone deformation] may depend upon the magnitude, direction, and duration of the applied forces, material properties of the body [bone], and the environmental conditions such as heat and humidity.”*

(Özkaya et al., 2017: 282)

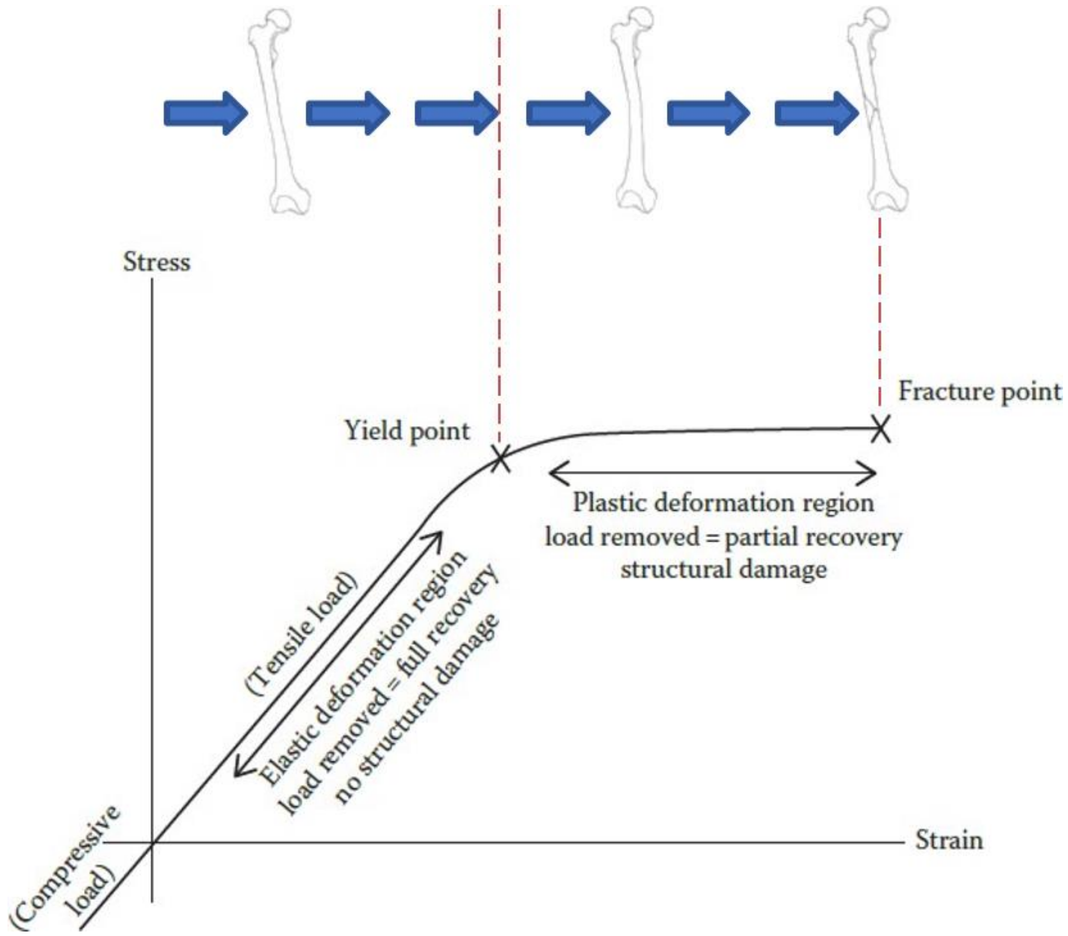

Figure 21: General stress-strain curve demonstrating Young's Modulus of Elasticity and associated state of bone. Modified after Symes et al., 2012: 347, fig. 17.1; 2014: 344, fig.13.1.

For example, when long bones are subjected to excessive dynamic force, spiral fractures can occur as a result of tensile shear failure of the bone collagen structure (Evans, 1973). Bonnichsen and Will (1990) note that in such cases, the forces involved produce fragments that tend to be irregular in shape and are usually longer than they are wide.

2.10 Types of Trauma

The majority of archaeological trauma analysis incorporates the terminology introduced and accepted within forensic anthropology and the medicolegal context, with trauma usually classified into the following three categories:

- Blunt force
- Ballistic force (projectile or penetrating trauma)
- Sharp force

Whilst the field of forensic anthropology also employs a fourth category: thermal (see Kroman and Symes, 2012: 228-229), the use of this term as a specific type of trauma is not common within archaeology, due to the inherent difficulties in identifying deliberate agency, although one recent report suggests some potential in this regard (see Alfsdotter et al., 2018). Instead, the effects of thermal alteration on bone are most usually viewed from the taphonomic perspective in archaeological assemblages,

Passalacqua and Fenton (2012: 405) point to the increasing numbers of skeletal trauma studies. Their review of published research in the *Journal of Forensic Sciences*, highlighted the surge in research in blunt force and projectile trauma at the beginning of the 1990s, with the investigation of blunt force injuries remaining prevalent much of the time since. Within bioarchaeology, healed (antemortem) blunt force injuries have been used as a tool for exploring rates of accident (Judd, 2006; Novak and Slaus, 2012) and general levels of violence (Brickley, 2006; Judd, 2006; Krakowka, 2017) in past populations, as well as addressing questions regarding recidivism (Judd, 2002). However, unhealed blunt force trauma, i.e. that occurring close to death has received much less attention. Even where strong evidence of warfare or interpersonal violence is present, observations and reports tend to prioritise the identification and description of sharp force trauma. It is evident that the comparative scarcity of reported peri-mortem blunt force trauma derives from the difficulties in distinguishing such fracture patterns, often complex in nature, from post-mortem breakage (see section on peri-mortem trauma below), the problems of interpretation (which can require an in-depth knowledge of biomechanical properties of different bones) in addition to the problems of conveying and reporting such information.

2.10.1 Blunt force

Blunt force trauma describes those changes wrought upon bone that are produced by low-velocity impacts involving blunt or broad objects (Kimmerle and Baraybar, 2008b: 151). Examples of such impacts in the modern context include beatings, road traffic accidents, concussive waves (such as those resulting from explosions), low-velocity projectile injuries (including some gunshot wounds) or low velocity impacts between a body and a blunt surface (e.g. trips/falls from height).

Within the modern context, accidental blunt force trauma occurs within a myriad of situations and is common in both urban and rural landscapes, particularly in industrial and agricultural contexts. In general, the archaeological evidence suggests a very similar prevalence in past populations, with Ortner stating:

> *"Dynamic fracture is the most common traumatic condition in archaeological skeletal material."*

(Ortner, 2003: 120)

The identification and reporting of blunt force trauma are therefore essential when considering overall patterns of violence in the past. If blunt force is under-reported, or even neglected altogether, levels of violent trauma in past populations may be vastly under-estimated. Furthermore, the comparative prevalence of sharp force trauma is likely to be over-emphasised where blunt force trauma is not reported or remains unidentified. Alongside these paleoepidemilogical issues, a lack of blunt force reporting will limit opportunities to develop and improve knowledge and understanding its identifying characteristics and their variation.

Concerning blunt force trauma, the origin of fractures and fracture propagation are subject to a broad spectrum of both intrinsic and extrinsic factors. Some of the main variables affecting bony responses to blunt force impacts are outlined in Table 3 overleaf:

Table 3: Factors influencing bone fracture propagation caused by blunt force trauma. After Smith et al.,2003; and Kroman and Symes, 2012: 220.

Intrinsic factors	Extrinsic factors
Bone morphology	Loading rate
Bone density	Loading duration
Bone mineralization	(Angle of stress)
Bone remodelling	
Bone buttressing	Object shape
Bone microstructure	Object weight

Of these influences, Kroman and Symes (2012: 230) state the most important extrinsic factors to be:

1. Force of the impact
2. Surface area of the impacting interface
3. Acceleration/deceleration rate

Within the realms of both clinical and forensic science, fractures have generally been grouped into an accepted set of categories, based on the types of stress (force) affecting bone under differing conditions (see Figure 20). Each of these stresses can be either dynamic (sudden, high stress) or diastatic (slow, increasing and cumulative) and they produce different types of fracture, yet it is important to recognise that individual fractures are often the result of one or more types of stress (Ortner, 2003: 120). In a similar manner to some materials in engineering (e.g. steel), fractures due to fatigue or accumulated stress may also occur in bone when it is subjected to an intermittent, yet excessive stress over an extended period of time.

Cranial blunt force injuries tend to result from impacts involving compressive forces, producing varying patterns of fracture (Ortner, 2003: 121). Two main groups of fracture typically manifest: burst fractures, usually simple, linear fractures, single or multiple, radiating away from the compressive site; and circular fractures, encompassing the compression site and typically producing depression within the cranial vault surface (Figure 22).

Compression fractures are produced by excessive impaction of bone with rapid loading, as might be expected when an individual trips or falls from a height, landing on a hard surface. Compression fractures also occur in the postcranial skeleton and are most readily observable in the spinal column where fractures of the vertebral body occur due to sudden compression (Ortner, 2003: 121).

Figure 22: Blunt force trauma to left parietal in a young adult individual, showing the point of impact (white arrow), with radiating fractures proceeding away and concentric fractures encompassing the general wider area around the impact. Original image: Murphy et al., 2010: 641, fig. 3.

Biological factors such as age may also influence the type of fractures occurring in individuals' bones. Ortner (2003: 122) notes that in younger individuals, bending stresses acting on long bones can result in incomplete transverse fractures associated with longitudinal splitting, producing a characteristic 'greenstick' fracture.

Deformation is common in blunt force traumas where the bone has more time to react to the slower impact, bending, deforming and eventually, if the loads exceeds both the bone's yield point and failure point, fracturing (Passalacqua and Fenton, 2012: 401). Thus, evidence of blunt force trauma can provide information concerning the type of loading (e.g. tension/compression) and directionality (Passalacqua and Fenton, 2012: 402, fig. 19.1).

Bone is stronger in compression than in tension (Currey, 1970: 217) and typically fails first under tension (although some exceptions have been reported (Love and Symes, 2004)).

Other authors warn that there are other factors influence aspects of fracture propagation, including fracture direction and final fracture shape (Galloway, 1999b; Smith et al., 2003).

A good example of a typical fracture resulting from blunt force trauma is the 'butterfly' fracture. Ortner (2003) provides a clear description, explaining how the direction of impact is indicated by the fracture morphology, which also demonstrates the tension and compression forces in play when a long bone suffers a blunt impact (see also Passalacqua and Fenton, 2012: 402, fig. 19.1; Berryman and Symes, 1998).

Essentially, the area of bone directly impacted comes under compression when a force is applied. In contrast, the opposite side of the bone is displaced in the direction of the force applied, causing it to come under tension. As bone is weaker in tension, it will fail first on the opposite side to that which the force is applied (see Figure 23A below). Moraitis et al. (2008: 4, tab le 3) have also suggested further examples of lesions associated with peri-mortem blunt force trauma such as 'bone tear' and/or the presence of a breakaway notch.

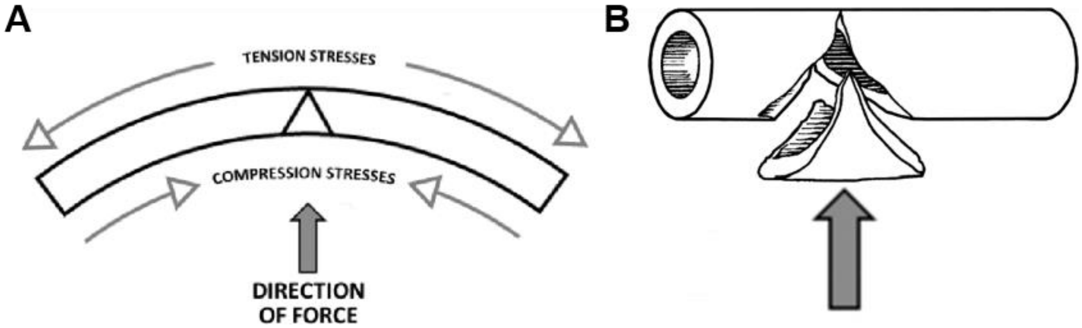

Figure 23: A) Illustrating the stresses and directionality of force involved in the production of a butterfly fracture. Adapted, with permission from Ubelaker, D. H. and Adams, B. J., Differentiation of peri-mortem and post-mortem trauma using taphonomic indicators, Journal of Forensic Sciences, 40 (3): 509-512 DOI: 10.1520/JFS13818J, copyright ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428; B) Schematic representation of the resulting fracture morphology in a long bone. Modified after Ortner, 2003: 123, fig. 8-7.

2.10.2 Sharp force

Sharp force trauma is the term used to describe injuries produced by an object which is either pointed or edged or both. Kroman and Symes (2012: 228) describe how sharp force can be conceptualised to form a subcategory of blunt force trauma, stating that sharp force is considered to occur at slower rates of loading. The main difference between the two involves the surface area of the interface between weapon/object and the soft and hard tissues of the body. The reduced surface area directly impacted by a sharp weapon results in the incisions and cut surfaces typically forming the evidence for sharp force trauma observed in skeletal material. Spitz (1993: 252) provides a clear description from the forensic perspective, where soft tissue injuries usually form the primary evidence, describing how "*…a cut (or incised wound), results whenever a sharp- edged object is drawn over the skin with sufficient pressure to produce an injury that is longer than it is deep*".

Sharp force injuries of bone can produce a range of different lesions, with Kimmerle and Baraybar (2008c: 265) stating that sharp weapons can result in incisions, cuts, chops, dents and crushing. It is important to note that as a subcategory under blunt trauma, sharp force may produce the same or similar fracture patterning. Thus, to the characteristic lesions above can be added concentric fractures and radiating fractures which Kroman and Symes (2012: 227) report as commonly associated with sharp force injuries.

Similar to blunt force trauma, extrinsic factors typically determine the type of sharp lesion produced, with the weight of the weapon and the pressure applied both constituting major influences. However, intrinsic factors, such as the biomechanical properties of the individual bone(s) affected, will also produce variation in skeletal injury characteristics.

In bone sharp force trauma classification is based upon the specific morphology of the fracture induced and any associated defects resulting. Sharp force trauma which penetrates or cuts deeply through soft tissues may leave toolmark impressions within more rigid tissues such as cartilage and bone (Tilstone et al., 2013: 423).

Even in the modern forensic context where soft tissues are often still present, Tilstone and colleagues have noted that assessing whether cutting wounds occurred during life or after death can be challenging (Tilstone et al., 2013: 423). The same is true regarding cut marks of bone which may still be produced after death. Post-mortem mortuary behaviour involving remains, such as defleshing or dismemberment, may therefore complicate the overall pattern of trauma, when peri-mortem injuries related to manner of death are present.

Peri-mortem cuts produced by swords have been shown to tend to be wider rather than deep and typically exhibit one burnished/'polished' wall (i.e. side) and one roughened wall. This smooth, 'polished' surface, most obvious where cortical bone is transected, can be used to indicate the directionality of the blade strike and the direction from which the blow came (Lewis, 2008b).

Stab wounds (i.e. penetrating sharp force injuries), however, are typically deeper than they are wide, with both edges exhibiting a relatively smooth texture/appearance (Kieser et al., 2012: 50, referring to Kanz and Großschmidt, 2006). With incised wounds, the resultant wound channel or groove is usually wider than the width of the blade which produced it

(Tilstone et al., 2013: 424). Stabs with smaller blades (i.e. knives/daggers, rather than swords) produce v-shaped notches in the bone.

In modern forensic contexts stab wounds are typically caused by knives, daggers or other bladed articles including scissors, but can also involve other tools or weapons such as ice picks, screwdrivers, an awl or simply a pointed stick. Stab wounds are typically produced through application of a weapon, either blunt or sharp, that directs the force of the blow onto a small surface area, typically with a thrusting, rather than slicing or slashing action.

In the medieval context, stabbing or penetrating wounds may have been produced by a number of different weapons or weapon attributes. For example, in the case of a pole axe, the wielder could use either the end of its shaft or its top spike to stab or thrust at an opponent. Similarly, a war hammer could potentially deliver a blow which ‘punches out’ a well-defined area of bone (see Figure 24), whilst a dagger is likely to produce a more typical linear ‘stab’ lesion, typified by a well-defined v- shaped cleft and/or incision. Other Medieval weapons which produced penetrating injuries similar to stabbing injuries included the spear, javelin, long-spiked maces (see Figure 15D), arrows of a variety of sizes and forms, and lances (regarding the latter, see Joinville’s account of its use in 2.5).

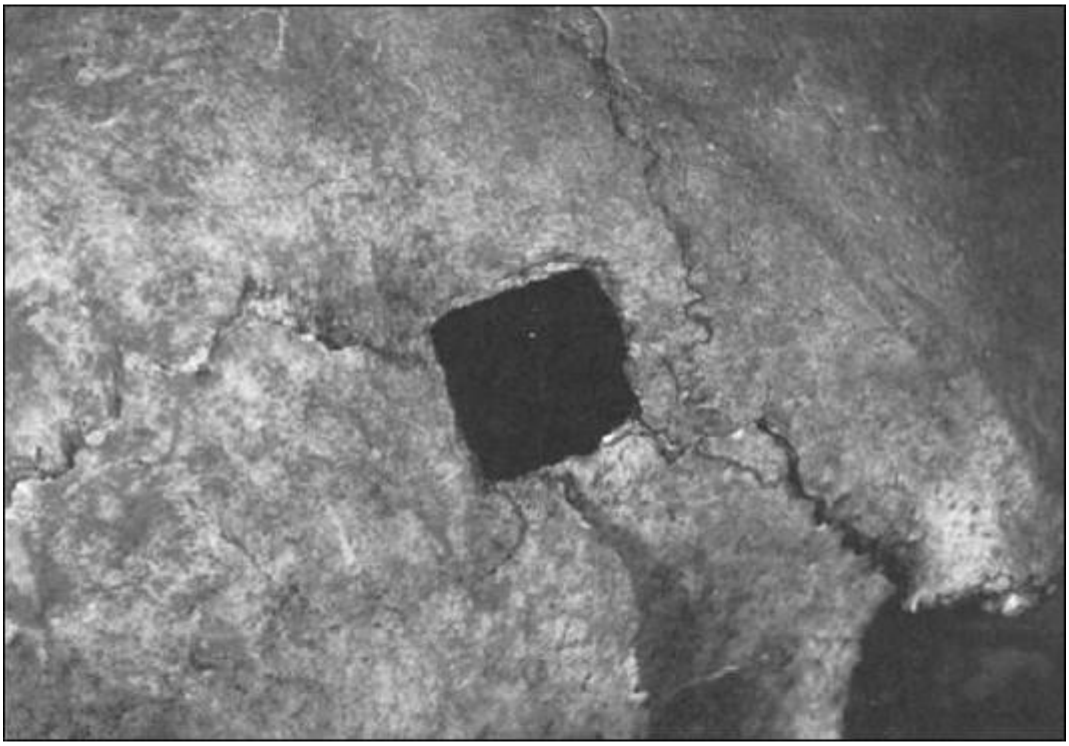

Figure 24: Penetrating trauma to the right parietal of an adult individual (Towton 9), interpreted as a poleaxe or war hammer injury. Note the angular form of the perforation and straight edges. Original image: Ortner, 2003: 139, fig. 8-30; see also original photograph in Novak, 2007: 99, fig. 8.10.

It is important to note that injuries which are primarily sharp force may also produce associated blunt force lesions (Symes et al., 2002) as observable in Figure 25. This is most likely in the case of heavier weapons such as swords, axes or machetes where the load applied, combined with the momentum of an assailant's upper limb swing (and any additional momentum in play, as in the case of a mounted assailant) is likely to be far greater than any bone can resist.

Figure 25: Two peri-mortem blade injuries of the left parietal and occipital. In each case one side or 'wall' is sharply defined, with the opposite wall irregular. Note also the upper wound is accompanied by associated radiating fractures indicative of a combination of sharp and blunt force suggesting a heavy weapon such as a sword or possibly an axe. Original image: Kjellström, 2005: 35, fig. 6.

However, intrinsic factors such as the morphology of the bone impacted, as well as the age of the individual or a pathological condition are also pertinent variables. For example, 'greenstick' fractures are more commonly observed in subadults (Ortner, 2003) and Moraitis and Spiliopolou (2006) similarly report 'delamination or bone tear' in a bone belonging to a child (see Figure 29).

2.10.3 Projectile force

The main difference between blunt force trauma and projectile injuries relates to the rate of loading at the point of impact on bone. With blunt force injuries, the force applied is comparatively slowly. Projectile injuries (also known as ballistic trauma), however, tend to involve much more rapid rates of loading. The difference in these rates of loading and the concurrent/consequent rate at which energy is absorbed by the bone, results in differing patterns of fracture (Passalacqua and Fenton, 2012: 400). With the more rapid rates of load seen in projectile injuries, bone has less time to deform before the load exceeds the yield and failure points and hence these impacts often produce increased numbers of fractures with minimal deformation, characteristics often reported in forensic cases involving gunshot injuries and blast trauma. The lack of deformation means fragments may more easily be reconstructed (Passalacqua and Fenton, 2012: 401).

Within archaeological contexts, projectile injuries can usually only be confirmed if the projectile itself remains embedded within the bone (e.g. Flohr et al., 2015; Figure 26A below). However, close association of projectiles to remains may provide strong contextual evidence (Mitchell et al., 2006), notably where any bone fracture characteristics are consistent with the form of the projectiles. Again, it should be noted that not all projectiles are sharp-edged, as demonstrated by the interpreted slingshot injuries at Maiden Castle (Redfern, 2009; see Figure 26B below).

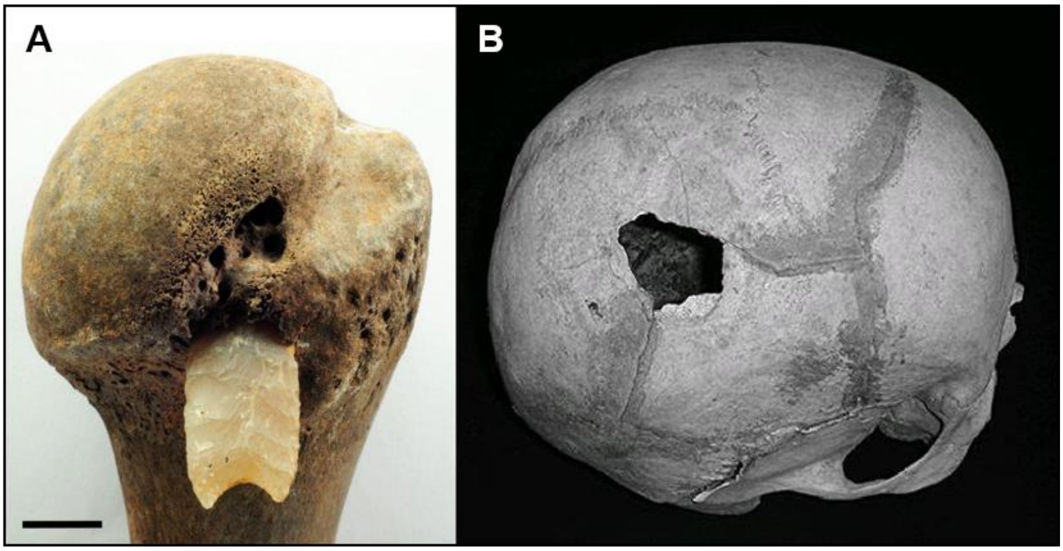

Figure 26: A) Posterior view, of flint arrowhead embedded in human right humerus (bar = 1cm). Modified after Flohr et al., 2015: 77, fig. 2; B) Superior view of an individual from Maiden Castle, showing evidence of a peri-mortem projectile injury. Modified after Redfern, 2009: 410, fig. 6.

2.11 Timing

Critical to the identification of traumata and other changes in bone pertinent to the interpretation of the context is the question of their timing. When considering individual lesions, the most immediate distinction necessary to make is that between changes to the bone which took place either prior to or around the time of death (antemortem/peri-mortem), and those changes which took place long after death and final deposition (post-mortem).

TIME →	→	→
Living	Death	
Antemortem	Perimortem - - - - - - - - - - -	Postmortem

2.11.1 Antemortem trauma

Injuries which took place earlier in life and which evidently did not result directly in an individual's death are termed antemortem. In both forensic and archaeological remains, antemortem trauma is most obviously interpreted through evidence of healing processes. The presence of new or remodelled bone directly associated with the trauma under consideration constitutes definitive evidence for healing or inflammation (Barbian and Sledzik, 1998; Lovell, 1997; Ortner, 2003; Sauer, 1998: 322). The genesis and development of such remodelled bone, following a fracture in living bone, is just one of a well-understood series of processes involved in the active healing process.

Bone fracture is often accompanied by damage to other tissues or organs, including the skin and the associated vascular systems. For example, blood vessels within the bone, including those within the periosteum, the marrow and the Haversian canals of the cortex, may also be ruptured, in addition to those in overlying muscle tissue. It is this soft tissue trauma that triggers the healing process. This commences with soft tissue processes (haematoma/clot formation and subsequent formation of a fibrous matrix, rarely preserved in archaeological remains (see Figure 27B), which lay the foundation for a new bony callus in endochondral bone. Assuming reasonable treatment and health, the new callus ultimately bridges the fracture. Remodelling of this new bone occurs in the medium term with conversion of the new ‘woven’ or fiber bone (again rarely preserved well in archaeological individuals) into denser, lamellar bone (Ortner, 2003: 126). Ortner (2003: 126) notes that although some authors combine some of these steps (cf. Paton, 1992:11), the general process and its sequence is accepted.

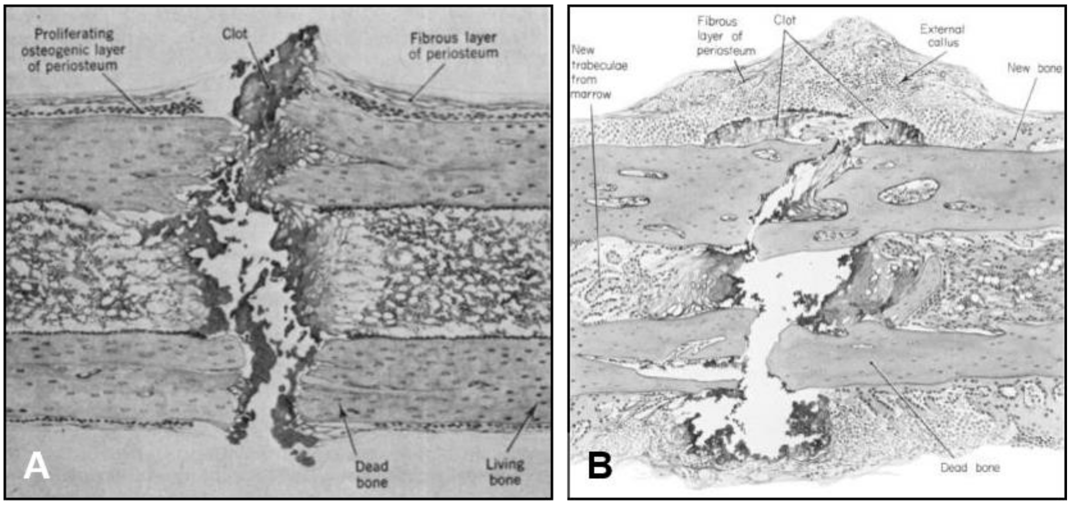

Figure 27: The healing process in bone – Left: Drawn section of a rabbit rib 24 hours after a fracture; Right: Initial callus formation after one week. Modified after Ham and Harris, 1971: 346, fig. 3 and 354, fig. 8 respectively.

It is the periosteal or bridging callus which usually forms the external macroscopic evidence of healing visible with longer-term post-mortem intervals where remains are skeletonised, as is normally the case with archaeological contexts (Ortner, 2003: 128).

Primary callus may take roughly six weeks to develop, under ideal conditions. However, union of the bone and return of adequate function are ‘too variable to predict’ (Ortner, 2003: 128) with this variability confirmed by other authors (e.g. Lovell, 1997: 145, table 3; Paton, 1992: 11), although certain trends are accepted such as Paton’s assertion that fractures heal twice as quickly in children as in adults (Paton, 1992: 11).

Essentially, the fresher the remains are (i.e. the least time since death) the easier it is to recognise and identify evidence for antemortem and peri-mortem trauma. At the microscopic scale, Ham and Harris (1971), working with rabbits, reported that proliferation of the periosteal osteogenic layer can occur within forty-eight hours of a living bone fracture. However, once decomposition has taken place, all cells will have died, and the periosteum is lost along with the organic evidence for any healing. Only calcified tissues, deposited during the later stages of healing, will remain in the longer term. The earliest evidence for healing identified in dry skeletal remains typically manifests as a slight remodelling of sharp edges in broken bone, usually resulting in a rounded appearance, with edges potentially appearing slightly 'polished' under the microscope. Figure 28 demonstrates an example of some of the earliest changes potentially visible in skeletal material.

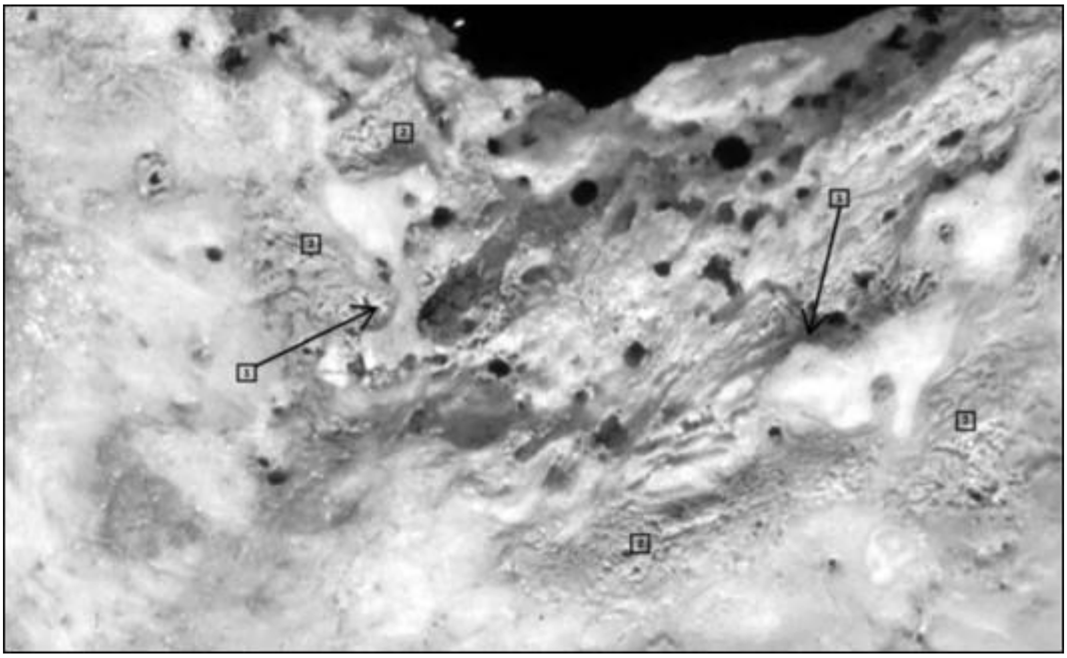

Figure 28: Cranial fracture showing early evidence of active healing, with osteoclastic (1) activity demonstrated by pronounced pitting and irregular or scalloped cortical bone surface edges; and osteoblastic (2) activity indicated by subperiosteal new bone deposition. Original image: Barbian and Sledzik, 2008: 264, fig. 1.

Such changes generally require a minimum of seven days before they become perceptible (Maples, 1986: 221). As a result, in such instances where injuries occurred within a week prior to death, it may be difficult or impossible to distinguish them from post-mortem insults. Thus, as Maples summarises: "*If there is any evidence of healing, absorption, or infection, then the trauma was antemortem.*" (1986: 220-221).

2.11.2 Peri-mortem trauma

Concerning the use of the term peri-mortem trauma, it is important to note the difference in its definition and use between the forensic and osteoarchaeological fields (see Knüsel and Smith, 2013c: 659-660). The modern forensic pathologist is most immediately concerned with identifying the cause, mode and manner of death of an individual, rather than investigating the nature of the timing of individual wounds. With this remit, the pathologist's use of descriptive term peri-mortem, refers only to those changes in the bone directly associated with or immediately preceding death. Thus, within the forensic context, Sauer states that "*Any injury directly associated with manner of death is considered a peri-mortem injury.*" (Sauer, 1998: 321).

Within the field of forensic anthropology, however, the term peri-mortem is used to attribute timing of changes in a bone's structural integrity and morphology to the specific period in which the bone was able to achieve the final form, regardless of whether these changes are directly attributable to the death event or not (Scientific Working Group for Forensic Anthropology [SWGANTH], 2011).

Given that changes attributable to peri-mortem timing are directly linked with the structural characteristics of the bone and the inherent biomechanics of its heterogenous organisation at both the microscopic and macroscopic scales, it follows that 'wet' and 'dry' bone fracture characteristics are distinctive. The majority of fresh or 'wet' bone fractures with no healing in evidence, occur close to the time of death and are therefore deemed 'peri-mortem'.

However, the period in which bone transforms from 'wet' (i.e. peri-mortem) to 'dry' appears highly variable and under certain conditions, bone may remain 'fresh' long after death. The factors influencing this variability are not yet well understood. Ubelaker and Adams (1995) reported on a forensic case in which they observed 'butterfly' fractures, typically thought only to occur in peri-mortem situations, manifesting in dry bone during their accidental excavation and recovery, long enough after death for the remains to have fully skeletonised, with other authors reporting additional exceptions (e.g. Moraitis and Spiliopoulou, 2006: 225). It therefore seems that at present, the situation has progressed little in the thirty years since Maples described peri-mortem trauma as: *"… an elastic interval at best and a vague concept at worst.*" (Maples, 1986: 221)

Passalacqua and Fenton (2012: 402) imply anthropologists can make only three determinations when assessing bone fractures:

1. If a fracture occurred in fresh bone and exhibits healing
2. If a fracture occurred in fresh bone with no evidence of healing
3. If a fracture occurred when the bone was in a dry state

They have also reported that some forensic anthropologists have suggested that the use of the term 'peri-mortem' be halted in favour of using the term 'fresh bone fracture' (Passalacqua and Fenton, 2012: 402).

Villa and Mahieu (1991, working with archaeological samples) and Quatrehomme and İşcan (1997, working with forensic cases) each associate peri-mortem fractures with smooth fracture edges (see Villa and Mahieu, 1991: 35, fig. 5b), usually the same colour/staining as the rest of the bone. One might argue that the former of these is less likely to be recognised in skeletal material, although it is quite possible that a blow may be sufficient to cause a substantial periosteal reaction which might subsequently calcify, leaving a remodelled appearance to the bone surface (e.g. ossified haematoma). Ortner (2003: 126) describes how the periosteum will typically be broken during fracture propagation (although this is not always the case, especially when immature or younger individuals are concerned), with the causal stress also having the tendency to strip/tear the periosteum from the surface of the bone up to a few millimetres, adjacent to the fracture site.

Moraitis and colleagues (2008: 4) have reported a number of different fracture characteristics they suggest are indicative of peri-mortem timing. In particular, they note that 'bone tear' has been observed in a variety of human bone types and different elements and their regions. These include long bones (tibia, fibula), irregular bones (vertebral arches, mandible) and flat bones (the scapular body). Table 53 provides a list of peri-mortem characteristics suggested to be associated with peri-mortem trauma.

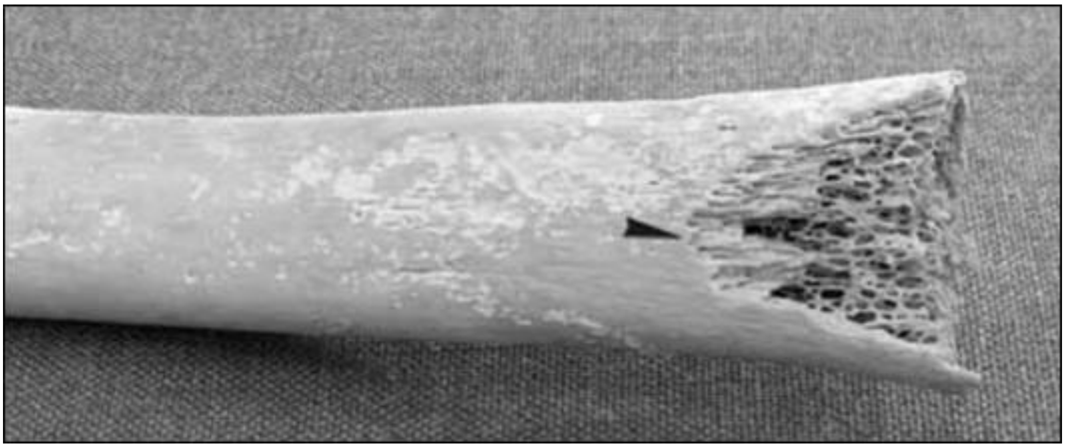

Figure 29: A transverse fracture to a child's distal radius, resulting from a fall from height. Moraitis and Spiliopoulou describe the small area of delamination or 'bone tear' (black arrow) associated with the peri-mortem fracture. Original image: Moraitis and Spiliopoulou, 2006: 224, fig. 5.

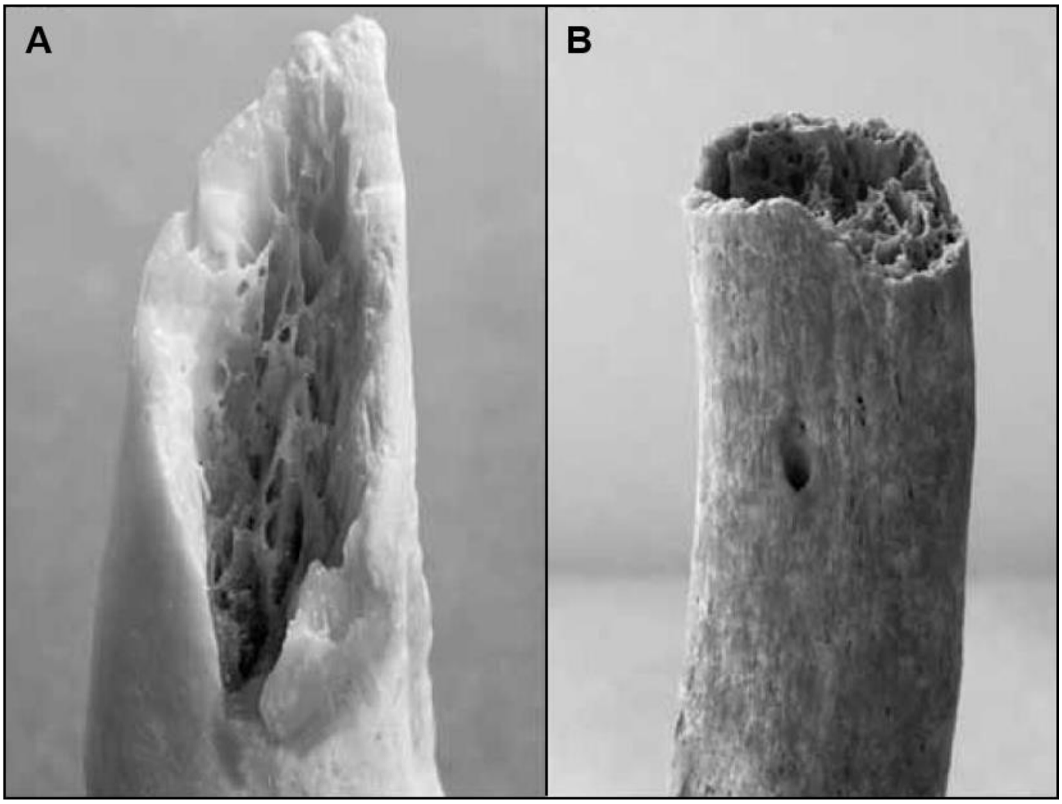

Figure 30: Peri-mortem versus post-mortem - Peri-mortem versus post-mortem - A) Peri-mortem fracture exhibiting helical breakage at an oblique angle across the main axis of the bone, with sharp-edges and bevelled fracture surfaces; B) Post-mortem fracture, with breakage almost perpendicular to long axis and with blunt edges and fracture surfaces exhibiting colour differentiation relative to unbroken surfaces. Modified after Moraitis and Spiliopoulou, 2006: 224, fig. 4.

Furthermore, the distribution of specific types of trauma has potential to indicate peri-mortem timing, as Maples suggested when he considered lesions attributed to scalping (Maples, 1986: 221). However, he was also one of the first to warn of the variable retention of bone elasticity, even over extended timeframes and well into the post-mortem period, stating that such ‘peri-mortem’ fractures (i.e. those with indications of elasticity) may be produced up to several weeks at least after death.

2.11.3 Post-mortem changes

As discussed above, peri-mortem fractures and post-mortem breakage can produce very similar fracture patterning (see Figure 31A-B) and the distinction between peri-mortem trauma and post-mortem changes remains one of the most challenging and important processes in trauma analysis (within both forensic and archaeological contexts (Galloway et al., 1999; Moraitis et al., 2008; Ubelaker and Adams, 1995; Wheatley, 2008;). Nevertheless, some types of bone alteration or breakage appear much more likely due to post-mortem causal factors. These include animal damage (due to a large variety of small to large species, not limited to true carnivores; see Figure 32 and Figure 33) and artificial dismemberment of remains (Byers, 2016; Johnson, 1985: 185; Lovell, 1997: 145; Maples, 1986: 222; Nawrocki, 2009; 2016; Shattuck, 2010; Villa and Mahieu, 1991). Table 54 outlines common breakage patterns reported associated with post-mortem factors.

2.11.4 Taphonomy

Symes et al. (2008) highlight the problem that different elements in a single set of remains may lose their organic component and shift from 'wet' to 'dry' stages at different times and/or at varying rates, depending on their differential decomposition or differential exposure to extrinsic taphonomic conditions (e.g. heat alteration). Consequently, different elements of the same individual might indicate differing fracture patterns, and equally those parts of an element impacted by the same peri-mortem injury may subsequently present quite different fracture patterning.

Johnson (1985) also notes that while the point of trauma impact may be clearly identifiable in fresh bone (see Figure 31A; cf Figure 31B, Figure 32 and Figure 33), its overt observation becomes increasingly difficult with time once taphonomic degradation and horizontal cracking commences. For instance, evidence of sharp force trauma, while potentially clear and obvious in the immediate post-mortem period, may be eroded, disguised and even lost or destroyed completely with increasing time since death (Nawrocki, 2009: 292, fig. 23.10). Archaeological assemblages therefore have greater potential to under-represent subtle peri-mortem evidence, especially that which may deteriorate or be lost once remains are uncovered and during excavation or post-excavation processes, as suggested by the possible penetrating trauma in context 4247 at Sidon, observed at the time of initial processing (see Section 5.3).

Where they occur, in the majority of cases taphonomic modifications of human bone constitute slow-load impacts. Plastic deformation or warping can occur post-mortem due to soil pressure/overburden (Marshall, 1989). However, Moraitis et al. (2008: 5) state that such changes, when they do occur in the ground are more often observed as a 'gradual curvature' compared with the contralateral bone and typically only affect individual bone elements.

Figure 31: Peri-mortem versus post-mortem - A) Peri-mortem butterfly fracture in distal fibula; B) Post-mortem butterfly fracture in a fibula. Moraitis and Spiliopoulou highlight the differences in morphology and colour of the fracture surfaces. The post-mortem-like splintering in (A) may be due to the subadult age of the individual. Modified after Moraitis and Spiliopoulou, 2006: 225, fig. 6.

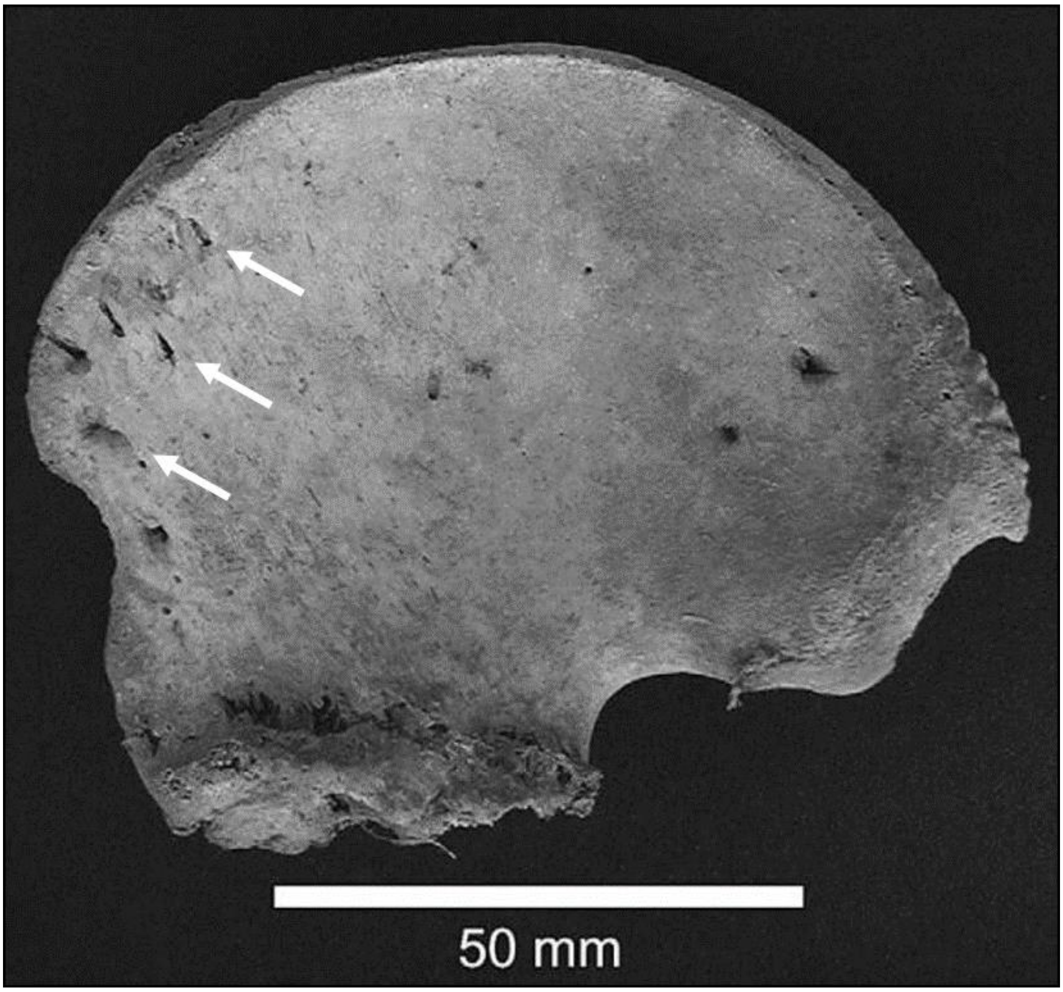

Figure 32: A subadult ilium exhibiting puncture marks caused by a dog. Modified after Esterhuysen et al., 2009: 1042, fig. 5.

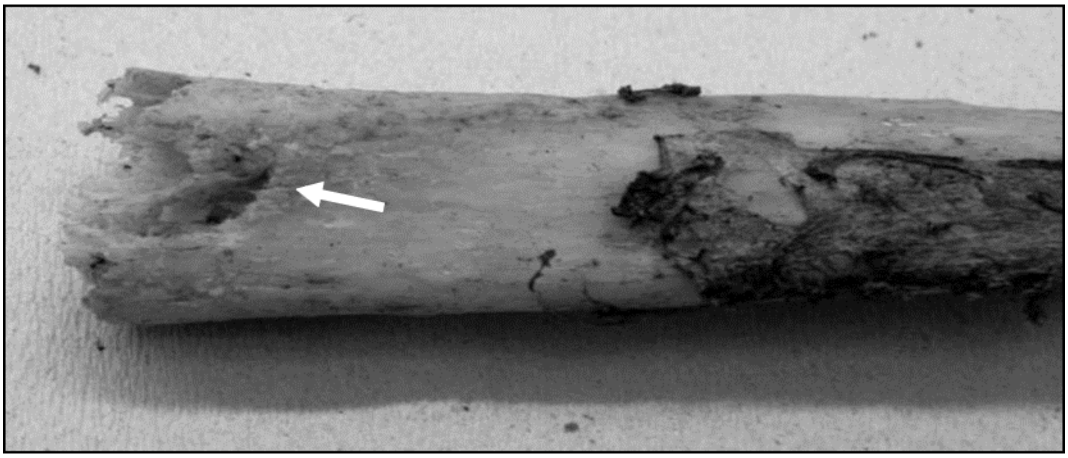

Figure 33: A distal fibula exhibiting substantial post-mortem breakage due to carnivore scavenging (white arrow). Modified after Moraitis and Spiliopoulou, 2006: 226, fig. 10.

3 THE ARCHAEOLOGICAL CONTEXT

3.1 Introduction

At the time of their discovery and excavation between 2009 and 2010, the general area of College Site was considered to lie along the main eastern line of fortifications of the medieval town (Figure 34). However, this assumption was derived primarily from a map produced by Dr Gaillardot in 1864 (Figure 35) to accompany the first volume of Ernst Renan's multi-volume Mission en Phénicie (Renan, 1864). The line of fortifications appears to have been based both on the limits of the existing urban fabric of the old town and on a projected line between the land castle at the southeast corner of the old town and the sea castle to the north, with little confirmation of the exact positioning of the fortification wall or details concerning the number and nature of its features.

In 2011, following completion of the excavation and recording of burials 101 and 110 in 2010, specific features (walls 9078 and 10160) in the area of the two burial deposits were re-interpreted and identified as the remains of the inner and outer edges of the late medieval town fortification ditch. This ditch ran north-south with a width spanning twelve to fifteen metres and to a depth of at least five metres and had cut through all earlier deposits down to this level (Doumet-Serhal, 2016: 8). The inner edge of the ditch was defined by a curvilinear wall (context 9078), 14m long, 1.9m wide, and 1.25m high, comprised of a maximum of three courses and a protruding foundation course of neatly shaped sandstone blocks alongside rubble backing. A second curvilinear wall (context 4049) was originally exposed in 2007 and initially considered potentially Roman in date. This wall has since been re-interpreted as representing the foundation course of the outer edge of the late medieval fortification ditch. The western elevation of the extant wall forms an arc measuring forty metres in diameter (Doumet-Serhal, 2016: 8).

The discovery of other structures, features and deposits since the excavation of burials 101 and 110 has contributed significantly to the context of these mass grave deposits. These recently uncovered archaeological remains include structures and features considered to represent a bridging area over the fortification ditch and associated fortified features, suggesting a fortified gateway with at least one large round tower directly associated (Figure 36, Figure 37, Figure 38, Figure 39).

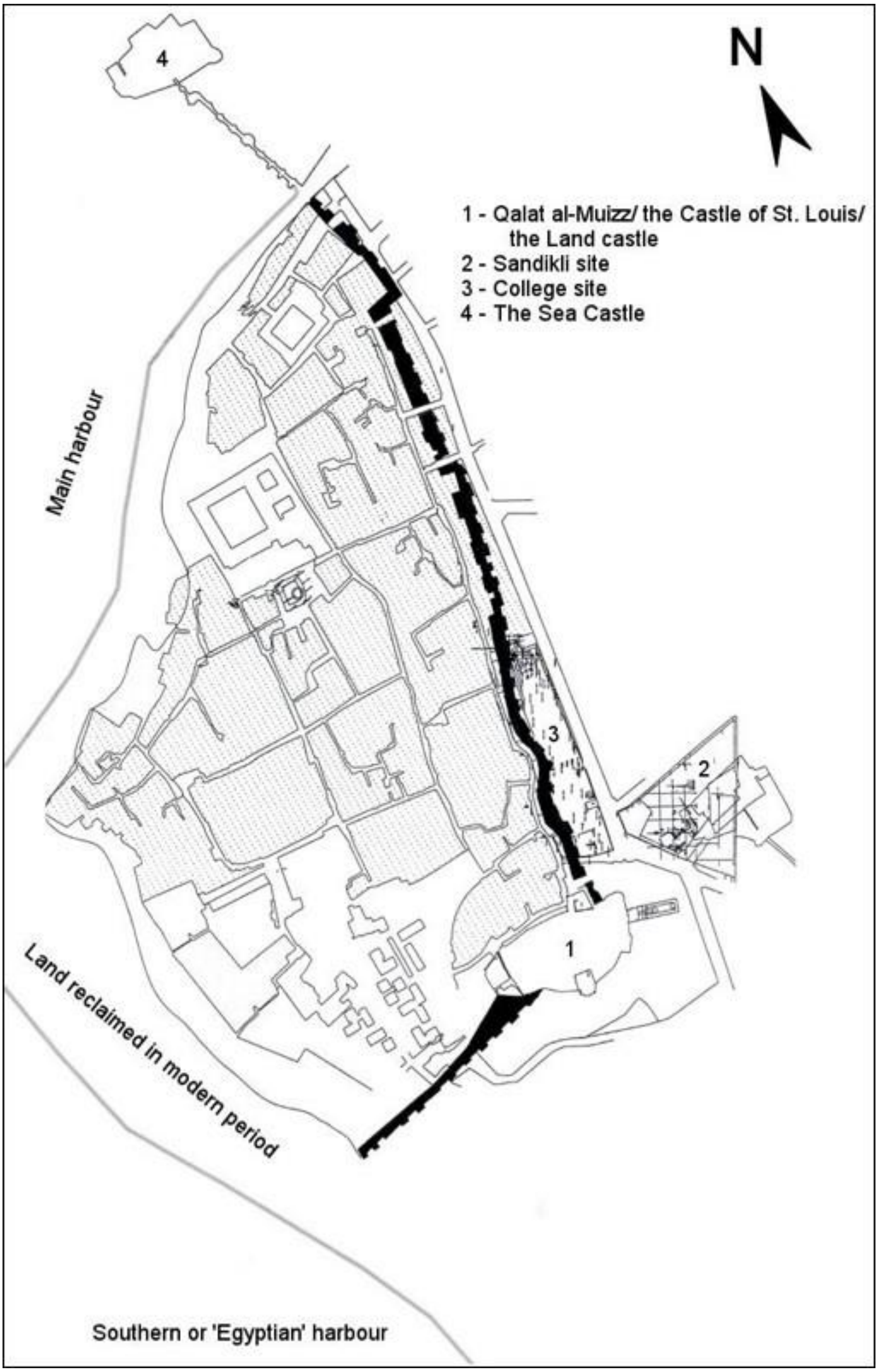

Figure 34: Map showing assumed line of medieval fortifications and locations of the downtown sites of archaeological interest (Modified after Doumet-Serhal, 1999: 29, fig.1. Original image: H. Barnes).

Figure 35: Gaillardot's map of Sidon in 1864 (included with Renan's initial volume of Mission en Phénicie, published in the same year), showing the location of the research excavations at College Site. Image courtesy of Dr. Claude Doumet-Serhal.

Doumet-Serhal (2016: 5) describes the walls of this gateway, stating that the external facing consisted of "*…well-worn square sandstone blocks with a rubble core or backing behind, in some cases with the addition of Roman columns as a strengthening and possibly a decorative feature.*" She notes that the latter construction technique (i.e. the re-use of classical marble columns as headers, see Figure 38 and Figure 39) is very similar to the walls of the sea castle (Figure 40 and Figure 41) and suggests that this part of the gateway is contemporary with the 13th century harbour castle. A lack of evidence for substantial remodelling or repair indicates the defences in this area derive from a single phase of construction.

Figure 36: College Site, Sidon, view looking northeast, showing the late medieval bridged gateway (foreground, centre) and the limits of the fortification ditch at the southern end of the site. Note the area of large block paving to the right of the curved ditch, considered to be a Roman road truncated by the cutting of the ditch, material from which was likely re-used in the construction of the medieval fortifications.

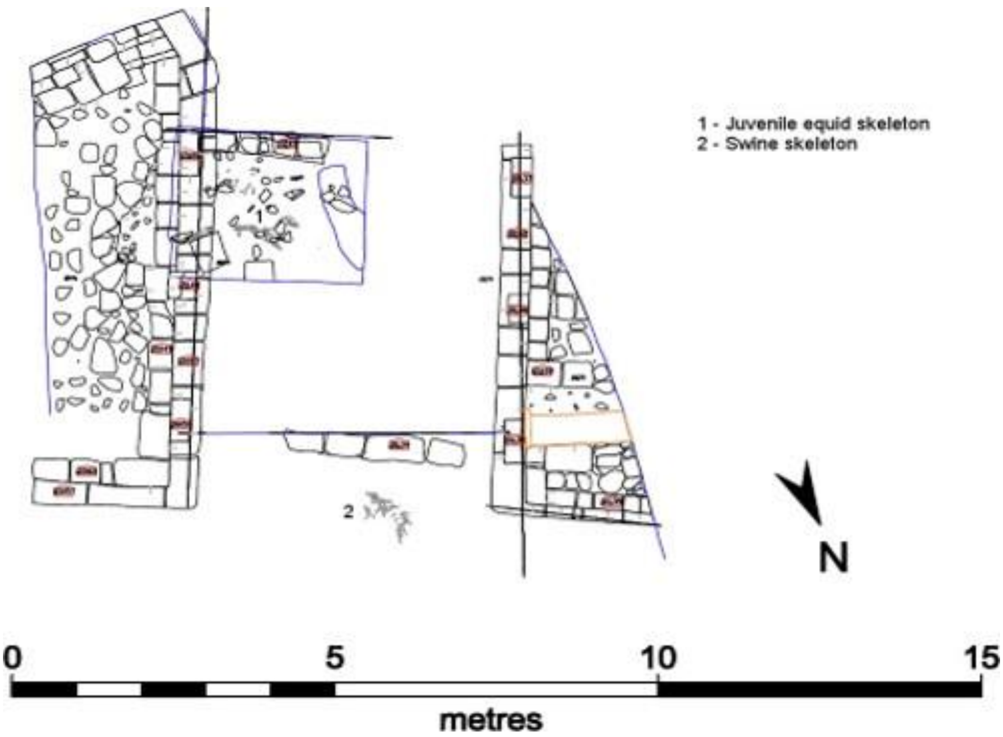

Figure 37: Plan of possible probable bridging area over fortification ditch, representing possible city entrance, showing positions of animal skeletons. Modified after Doumet-Serhal, 2016: 11, PL. 7. Reprinted with permission from the Editor, Faculty of Arts and Sciences, American University of Beirut and the author Claude Doumet-Serhal.

Figure 38: College Site, Sidon: Wall 10138, view looking northwest, showing re-use of antique marble columns in the construction of the western side of the interpreted late medieval gateway area.

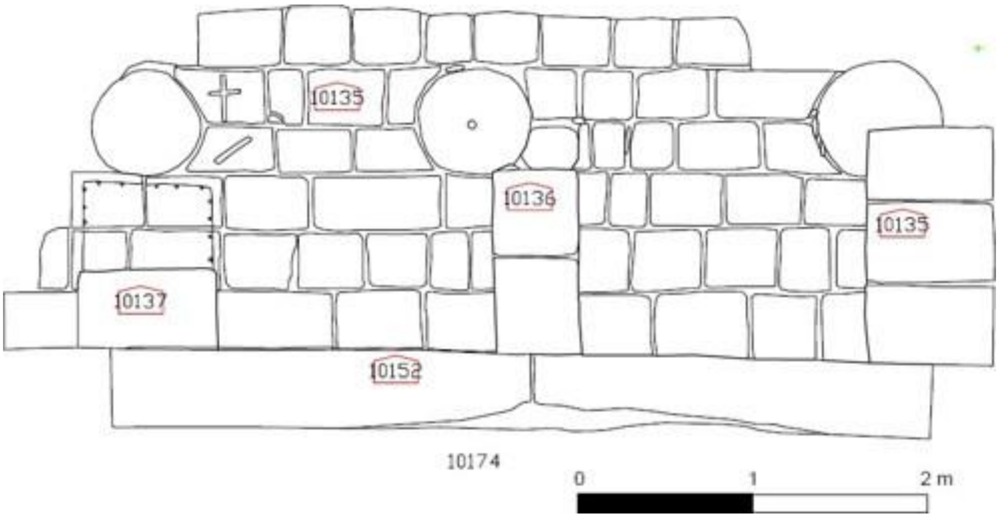

Figure 39: East-facing elevation of wall 10138, showing marble columns re-used as headers and possible masonry marks on two faced blocks (adjacent to left-most column in drawing). Original image: Doumet-Serhal, 2016: 11, PL. 6. Reprinted with permission from the Editor, Faculty of Arts and Sciences, American University of Beirut and the author Claude Doumet-Serhal.

Figure 40: The Sea Castle, view looking northwest, showing the construction technique incorporated into the modern reconstruction of the castle's perimeter.

Figure 41: The Sea Castle, Deschamps' aerial photograph, looking north, demonstrating the column-header construction technique was present in the square building (centre right), thought to date to the crusader period, prior to the modern reconstruction of the sea castle. Original image: Deschamps, 39th Levant Air Brigade, 1930s.

3.2 Associated Deposits

Alongside these built features, other associated deposits excavated and recorded within the ditch in the immediate vicinity of this interpreted gateway and close to burials 101 and 110 also contribute to their late medieval context. Robbing activity or other later truncation appears to have been limited at the southern end of the fortification ditch, with well-preserved evidence of late medieval occupation levels constituting approximately 0.5m of deposits represented within a sequence of sandy layers contained by the ditch. Doumet-Serhal suggests that the ditch "*… was regularly cleaned and cleared down to the foundations of the wall…*" and implies the thin layers of sand interspersed between the deposits may represent beach sand brought in to line the base of the ditch (Doumet-Serhal, 2016: 9). These deposits included substantial animal skeletal remains representing several almost complete equid and porcine remains (see Figure 37 and Figure 42).

Further north, yet still in the vicinity of both the gateway and burials 101 and 110, only a single medieval deposit remained within the ditch. Overlying this deposit was an isolated human cranium and mandible (context 10153) with several associated cervical vertebrae. This head was not associated with any other human remains and was found close to the base of the inner ditch wall (9078), i.e. possibly at the base of the interpreted round tower that forms the northern aspect of the bridging area/gateway.

In addition, at least one complete large, worked stone sphere and fragments of at least one other similarly-sized stone sphere were recovered from a rubble-filled cut (Doumet-Serhal, 2016: 12), probably associated with the clearing of the ditch. The size and weight of these worked stones suggest they represent projectiles, likely hurled by a large siege machine such as a counterweight trebuchet and characteristic of the crusader period of medieval warfare.

Doumet-Serhal (2016: 12) reported that a layer of rubble measuring half a metre directly overlay these late medieval deposits and suggested this thick, compact deposit demonstrated that rapid collapse of the defensive fortifications within a short space of time, arguing that the lack of silt or thin layers of detritus precluded a slower process of in-filling. She also highlighted the presence of a large piece of intact masonry suggesting the defences were actively pulled down (Doumet-Serhal, 2016: 12).

Figure 42: College Site, looking southwest along the late medieval ditch towards the internal side of the bridging area, showing one of the animal skeletons *in situ*.

3.3 Burial Location

It is now clear that burials 101 and 110 were located within the medieval town fortification ditch of Sidon, towards the southern end of the main north-south fortification line considered to enclose the old town core dating to the medieval period (see Figure 43 and Figure 44). The two deposits were situated immediately northeast of what is currently interpreted as a fortified gateway.

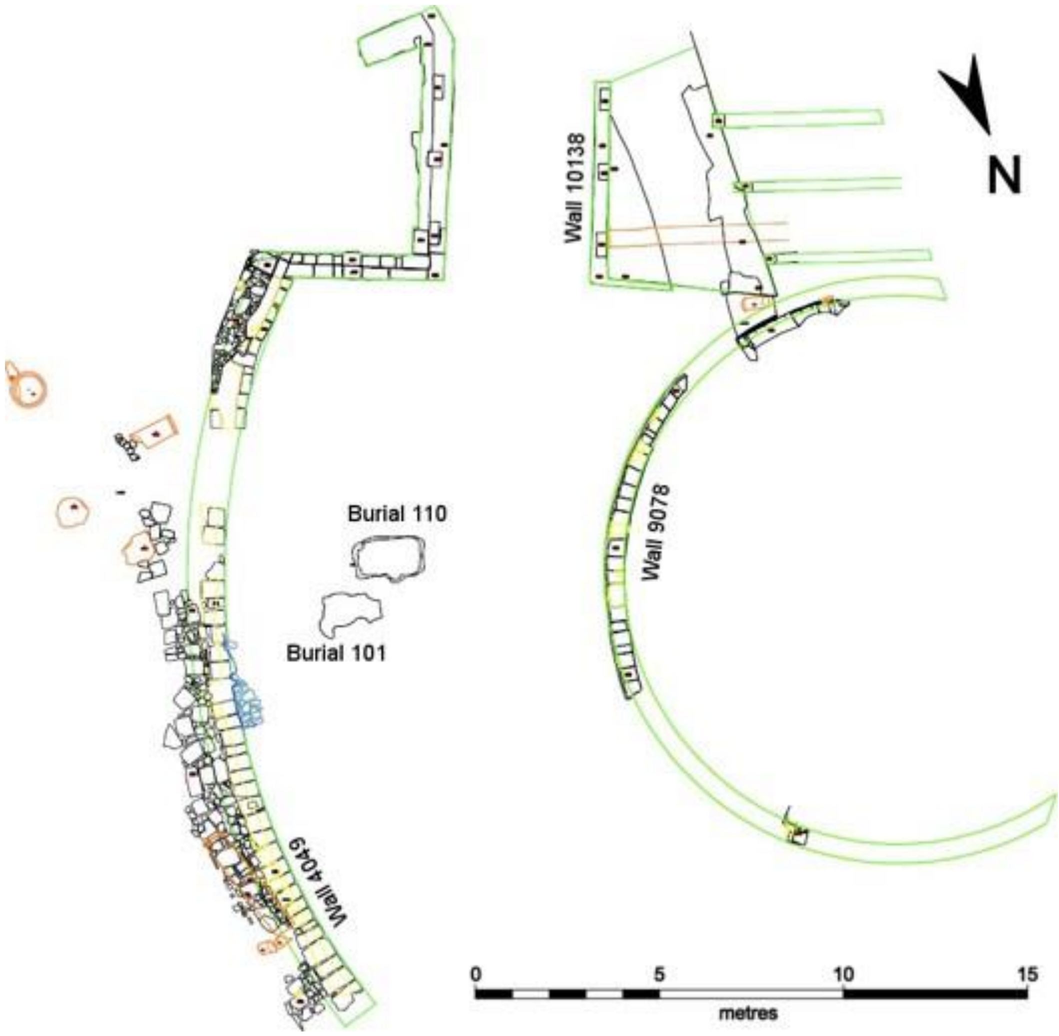

Figure 43: Plan of southern end of medieval fortification ditch, showing associated features and burials 101 and 110. Modified after Doumet-Serhal, 2016: 7, PL. 5a. Reprinted with permission from the Editor, Faculty of Arts and Sciences, American University of Beirut and the author Claude Doumet-Serhal.

Figure 44: College Site, rectified aerial photograph of southern end of medieval fortification ditch. Annotation demonstrates the inner and outer edges of the ditch and position of burials 101 and 110. Image courtesy of Dr Claude Doumet-Serhal.

3.4 The Burial Features

3.4.1 Burial 101

The deposit known as burial 101 was situated less than a metre from the northeastern limits of burial 110. The skeletal remains appeared isolated with no clear evidence of a grave cut and directly overlay a group of stones interpreted as an Iron Age post or column pad. The remains associated with the deposit spanned an irregular area with maximum dimensions of just under three metres east-west and approximately one and a half metres north-south (see Figure 45), with the majority of the remains concentrated within a slightly smaller area within. The extant human remains consisted mainly of whole limbs and body parts or body sections. The most complete set of individualised remains (context 4147) represented a torso, neck and head, and right upper limb. In general, the skeletal remains were in good condition, demonstrating only minimal evidence of weathering.

Several human bone elements/articulations on the margins of the deposit exhibited breakage of the bone elements. There was also evidence of marked burning/blackening of some elements; there was no discernible pattern of distribution to this charring except that it tended to be well-defined and generally occurred on or close to the broken ends of long bones (see **Error! Reference source not found.**), although some cranial material a lso exhibited similar sharply delimited areas of charring.

There was no obvious formal positioning to the articulated remains, although it was noted that context 4147 exhibited an unnatural angulation of the mid- spine, with the head and neck at right-angles to the extant lower thoracic spine. The burial matrix consisted of a relatively compact fill with no obvious evidence of in situ burning, except for those human skeletal remains which exhibited well-defined but minimal charring.

A single complete, roughly-hewn stone figurine was recovered from amongst the remains of burial 101, close to the top of the deposit. No other finds were directly associated with burial 101.

Figure 45: Burial 101, mid-excavation rectified photograph, showing the generally good degree of articulation retained in the limbs and body sections. Image courtesy of Dr Claude Doumet-Serhal. Original image: M. Williams.

Figure 46: Burial 101 – A-B) Examples of well-defined charring of some bones (black arrows). Note also, single isolated charcoal deposit (white arrow).

3.4.2 Burial 110

The long axis of the rectilinear grave cut for the mass burial pit (context 4202) was aligned along a roughly east-west axis. No consistent or deliberate orientation was able to be discerned for any of the human remains contained within the mass burial pit and the general degradation of articulation of the human remains, with limited numbers of 'first-order' relationships able to be discerned (see Knüsel and Robb, 2016: 657), indicates the remains within burial 110 represent secondary depositions within the pit.

Figure 47: Burial 110, view looking northeast, mid-excavation photograph showing the immediate area and the alignment of the rectilinear pit cut. Note the northern side of the pit has partially truncated an Iron Age post pad.

Figure 48: Burial 110 (Layer 6), mid-excavation photograph, view looking west, showing mixed deposit of disarticulated and partially articulated human remains, representing secondary deposition of body parts or sections. Image: R. Mikulski.

Of note, was a concentration of articulated/partially articulated pelvic bones, including at least one complete pelvis, found in the eastern third of the mass burial pit. Again, these lacked any consistent orientation or positioning (some being prone, some on their side, others supine), but their grouping suggests they were deposited together at this end of the pit. Fragmented cranial material was spatially distributed regularly throughout the pit and at all levels, with only a single complete cranium and mandible identified (context 4213), located quite neatly lying on its left side within the northeast corner of the pit (see Figure 48). The position of this cranium and the presence of several articulating cervical vertebrae suggest the possibility that the decapitated head was placed there deliberately and with some care.

Figure 49: Burial 110 (Layer 2), looking northeast, single perspective snapshot of 3D photogrammetric model of eastern half of burial 110 during 2009 season of excavation.

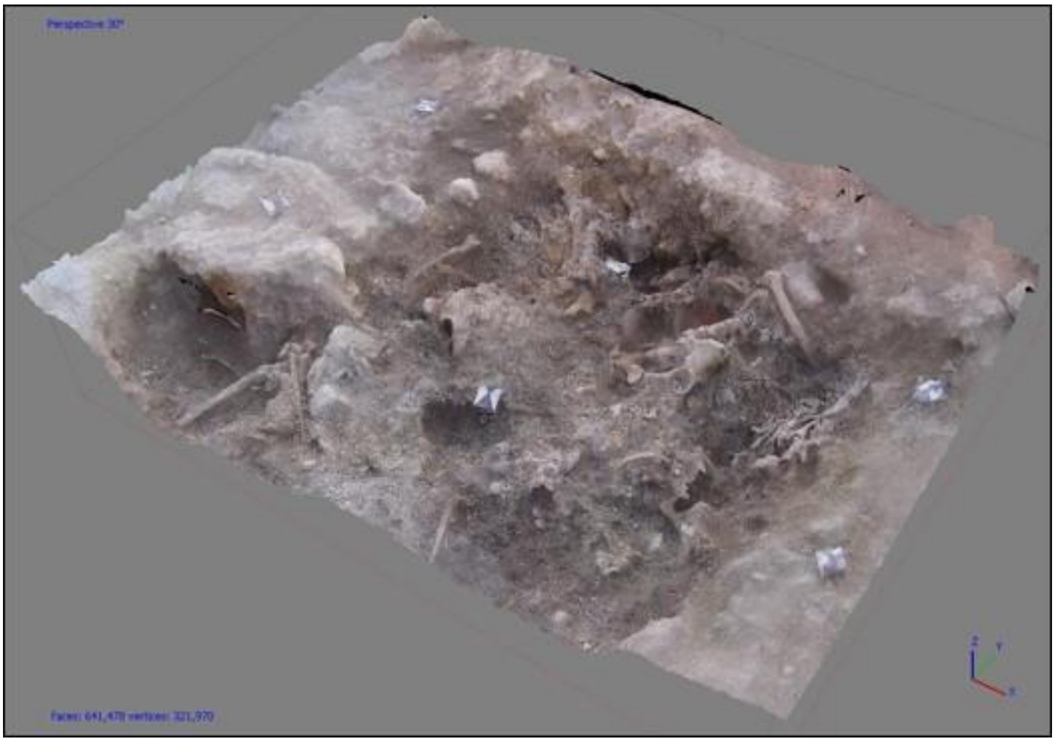

Figure 50: Burial 110 (Layer 3), looking northeast, single perspective snapshot of 3D photogrammetric model of eastern half of burial 110, during 2009 season of excavation.

Figure 51: Burial 110 (Layers 2 - 3), mid-excavation photograph, view looking northeast, showing articulated pelvic element groupings at eastern half of burial 110, during 2009 season of excavation.

The most persistent joints retaining articulation involved the lower limb, in line with expectations (see Knüsel and Robb, 2016: 658). The most substantially articulated, single set of remains observed constituted the upper torso, neck and majority of the head of one individual, along with the humeri represented by contexts 4246 (right humerus), 4247 (thoracic, cervical and cranial remains) and 4269 (left humerus and shoulder). The torso of this individual lay supine in the southeast quarter of the pit, at its base and was aligned along a roughly southeast-northwest axis, with the extant cranial remains lying in the southeast corner. The humeri were both splayed, with the right humerus extending in a northerly direction and the left humerus directed westwards.

The matrix within burial 110. In layers 4 and 5 (i.e. mid-way down through the pit), the matrix was fairly loose and included many voids most likely as a consequence of the deposition of a large variety of unsorted materials including both disarticulated and at least partially articulated human remains; burnt and calcined bone; several large, unburnt animal bone elements; small and large stones; a variety of man-made materials including metal objects, glass and ceramics (as represented by the small finds recovered from the pit); organic plant remains; sediment and ash. The most heavily burnt region of the matrix appeared to be located at the top of the deposit, in more-or-less the centre of the pit, slightly towards the south (i.e. the area represented by grids C, D, E and F during the 2010 season of excavation); other areas with concentrated evidence of burning included the southeast the southwest corners of the pit.

A limited quantity of pottery sherds was recovered from the fill of burial 110. These represented storage jars and imported Greek Attic ware, with the majority attributed to the Late Iron Age. A head of a clay figurine of a lion, also dating to the Late Iron Age was present as well.

Metal items included both iron and copper alloy objects. Amongst these was a large number of iron nails and tacks found scattered throughout the remains within the pit. These nails were broadly grouped into two types: the majority (37) consisted of a large nail type with stems of squared section and circular heads of 1.60 – 2.50 cm diameter and 5 – 8 cm in length. Twenty-two others were more akin to tacks, with heads measuring 1.0 – 1.14 cm in diameter and lengths of 1.80 – 2.15 cm. Virtually all of the tacks and many of the larger nails had bent ends, indicating they had been used and suggesting they had probably been nailed to one or more wooden artefacts which had not survived (Collins, 2012: 421). In addition, several iron objects were present, consisting of small, flattened pieces bent at right angles and possibly representing fittings from wooden furniture or structures. A small, silver, finger ring was also recovered (Figure 52C).

Of particular note were a number of copper alloy buckles and/or harness fittings. In total, these included four plain, circular single loop buckles with a central pin bent around the frame (see Figure 52F-G); three plain rings of a similar size to the circular buckles but lacking any evidence of pins; and a single, more unusual, kidney-shaped buckle with its pin. This distinctive buckle was finely made and exhibited some decorative detailing in the form of incised lines across the top of the pin and to both ends of the strap bar, the latter forming fingers grasping the bar (see Figure 52E). Three of the copper alloy rings preserved evidence of organic residue on their surfaces, exhibiting well-defined distributions suggesting the rings were originally attached to straps or harnesses of some sort, most likely of cloth or leather. Alternatively, they may have been sewn into organic material (Collins, 2012: 423). Three of these objects (one circular buckle, one ring and the kidney-shaped buckle with hands) exhibited traces of a red-gold colour on their surfaces, suggestive of gilding.

A single, small, leaf-shaped and socketed copper alloy arrowhead (Figure 52D) found in burial 110, constituted the only potential weapon recovered from either of the two mass grave deposits.

The arrowhead from burial 110 compares well with a similarly socketed copper alloy arrowhead recorded on the Portable Antiquities Scheme Database found at Scaftworth, Nottinghamshire, UK, although this English example is attributed to the Bronze Age, c. 1150 – 800 BC (Marshall, 2005). It compares less favourably with another example found at West Haddon, Northamptonshire and attributed to the Medieval period (Clark, 2014; Collins, 2012). A further British example reported on the database is perhaps more similar in form, but made of iron (Vandyck, 2014). Other comparative medieval examples derive from a 12th century context in Folkestone and a 13th century context at Rayleigh Castle, Essex (Collins, 2012).

Three sediment samples taken from the regions of the pelvic bones within burial 110 yielded both environmental and possible dietary evidence in the form of pollen with identified specimens mostly belonging to either Poaceae or Fungi taxa, and a small proportion of *Vitis vinifera*, (grapevine) grains also present. In addition, one pelvic sediment sample also presented evidence of olive. Two of the samples comprised ten percent cereals and pasture grasses, with these plants representing only three percent of the pollen composition in the third sample. Interestingly, and in contrast to samples taken from Middle Bronze Age deposits at College Site, the late medieval samples from burial 110 showed no evidence of pine pollen (Scott-Moncrieff, 2011: 35-36).

Figure 52: Some of the metal artefacts recovered from burial 110: A-B) Base silver *denaro* of Frederick II, c. 1245-1250; C) Silver ring with overlapping terminals; D) Cu alloy arrowhead; E) Kidney-shaped buckle with incised hands; F-G) Circular buckles. Images courtesy of Dr Claude Doumet-Serhal.

Other environmental indicators from burial 110 included possible evidence of insect activity. The corrosion on a small copper alloy pin head recovered from the grave fill, had preserved a possible imprint of an insect larva (see Figure 53). Unfortunately, hitherto it has not been possible to confirm this identification and/or identify the species responsible.

Figure 53: Detail of copper pin head recovered from fill of burial 110, showing possible insect larval imprint. Original image: P. Pearce.

3.4.3 Summary

It is clear that burials 101 and 110, the archaeological deposits associated with these features, and their location within what is now known to be the town fortification ditch at Sidon, constitute a unique opportunity both for insight into the Late Medieval period of the city and to test the contemporary accounts relating to its history. The breadth of evidence incorporates architectural structures, environmental evidence, human remains, material culture, all within a rare palimpsest characterised by the medieval town's fortifications and what was evidently once a main gateway into the town.

The current study sample is outlined in the following chapter. The methods applied to characterise the human remains and assess the evidence for peri-mortem trauma and their taphonomic history are described in relation to the Sidon samples.

4 MATERIALS AND METHODS

4.1 Materials

4.1.1 Location

This study focussed on the analyses of commingled and fragmentary human skeletal remains deriving from two mass grave deposits within well-stratified archaeological deposits dating to the late medieval period at College Site, Sidon, Lebanon.

Figure 54: Continental map of Europe and the Mediterranean, showing location of Sidon, Lebanon.

4.1.2 College Site, Sidon

College Site is situated in the modern coastal port city of Sidon in South Lebanon, located roughly halfway along the Eastern coast of the Mediterranean, approximately 43 kilometres south of Beirut and 34 kilometres north of Tyre. Sidon is somewhat unusual in that the city retains much of its Medieval structure and fabric in a condensed and well-defined area focussed on the northern harbour. With an occupation span of over 5,000 years, Sidon lays claim to being one of the oldest cities in the World, with unparalleled stratigraphy and archaeological deposits representing almost every major empire associated with the Eastern Mediterranean over the last 4,000 years. Sidon was important during the Crusader period and, along with the other major coastal ports of Acre, Caesarea, Tyre, Beirut, Byblos, Tripoli and Antioch, it formed the backbone of the Frankish states in the Near East, providing an essential supply centre through which the crusader settlers were supported by the Western Christian powers (see 1.6 and 2.3 for more detailed information on Sidon's history).

Figure 55: Aerial photograph, looking south over Sidon, 1934. Original image: Poidebard and Lauffray, 1951: PL. VII.

The city occupies an immediate coastal position, with the surrounding geographic landscape constituting a coastal plain broadly delineated by two rivers: the Nahr el-Līṭānī to the south and the Nahr el-Awalī to the north and bordered by the foothills of Mount Lebanon to the east (Carayon et al., 2011; Sanlaville, 1977).

The main excavation site lies almost immediately north-northeast of the castle of St. Louis (Qalat Al Muizz), running along part of the landward (eastern) edge of the old town district, between it and the modern road which encloses the eastern half of the old town and connects the northern harbour (along with its heavily reconstructed crusader period sea castle) to the area immediately southeast of St. Louis' Castle (Figure 34, Figure 55 and Figure 56).

Figure 56: Satellite image showing Sidon and area of College Site excavations (red), with main crusader fortified sites labelled (yellow) (Map source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IG.

Analysis was made possible, courtesy of the Lebanese Government's Directorate General of Antiquities (DGA), specifically Ms Myriame Ziade and Dr Sarkis Khoury, who kindly approved and facilitated the transfer of the skeletal material for anthropological and scientific analyses from the DGA building at College Site, Sidon (Lebanon) to the Department of Archaeology, Anthropology and Forensic Sciences at Bournemouth University (Talbot Campus, Bournemouth, United Kingdom).

4.1.3 The Human remains

The skeletal human remains which form the subject of the current research derive from archaeological human skeletal material excavated between the 2009 and 2010 seasons at College Site, Sidon, Lebanon. Following storage on-site between 2010 and 2011, these remains were transferred to the UK, where they were initially stored at the University of Exeter until 2013, before being transferred to the Cornwall Council Historic Environment Storage facility in Scorrier, Cornwall. In November 2015, the remains were transferred to the Department of Archaeology, Anthropology and Forensic Science on Bournemouth University's Talbot campus in Bournemouth, Dorset, UK, where they are currently curated.

The main deposit (burial 110) has previously been dated to the crusader period (1097 – 1291), based on a radiocarbon date from a disarticulated human femoral fragment recovered from the top of the deposit (Collins, 2012: 418). During initial excavation of burial 101 and the exposed eastern half of burial 110 in 2009, it was quickly observed that some of the articulated remains and disarticulated elements exhibited evidence of violent peri-mortem trauma. Although remains representing multiple individuals presenting potentially battle-related traumata were recognised as early as the end of the 2009 season, it was not until all articulated remains, disarticulated elements and identified fragments had been examined (with some re-fitting taking place in the process), that a fuller appreciation of the full extent of this trauma could be achieved. Details regarding the various contexts and human remains are provided in APPENDIX A3: Human remains with individual context numbers.

This research specifically investigates the human skeletal remains from burials 101 and 110, examining them in detail through the application of multiple analytical procedures, as well as their associated funerary contexts. Figure 57 illustrates the well-defined nature of these deposits, situated within the southern end of the main north-south line of the medieval fortification ditch at College Site, Sidon. Chapter 3 provides detailed information on the archaeological context and Figure 44 provides a detailed aerial view of the area of the burials.

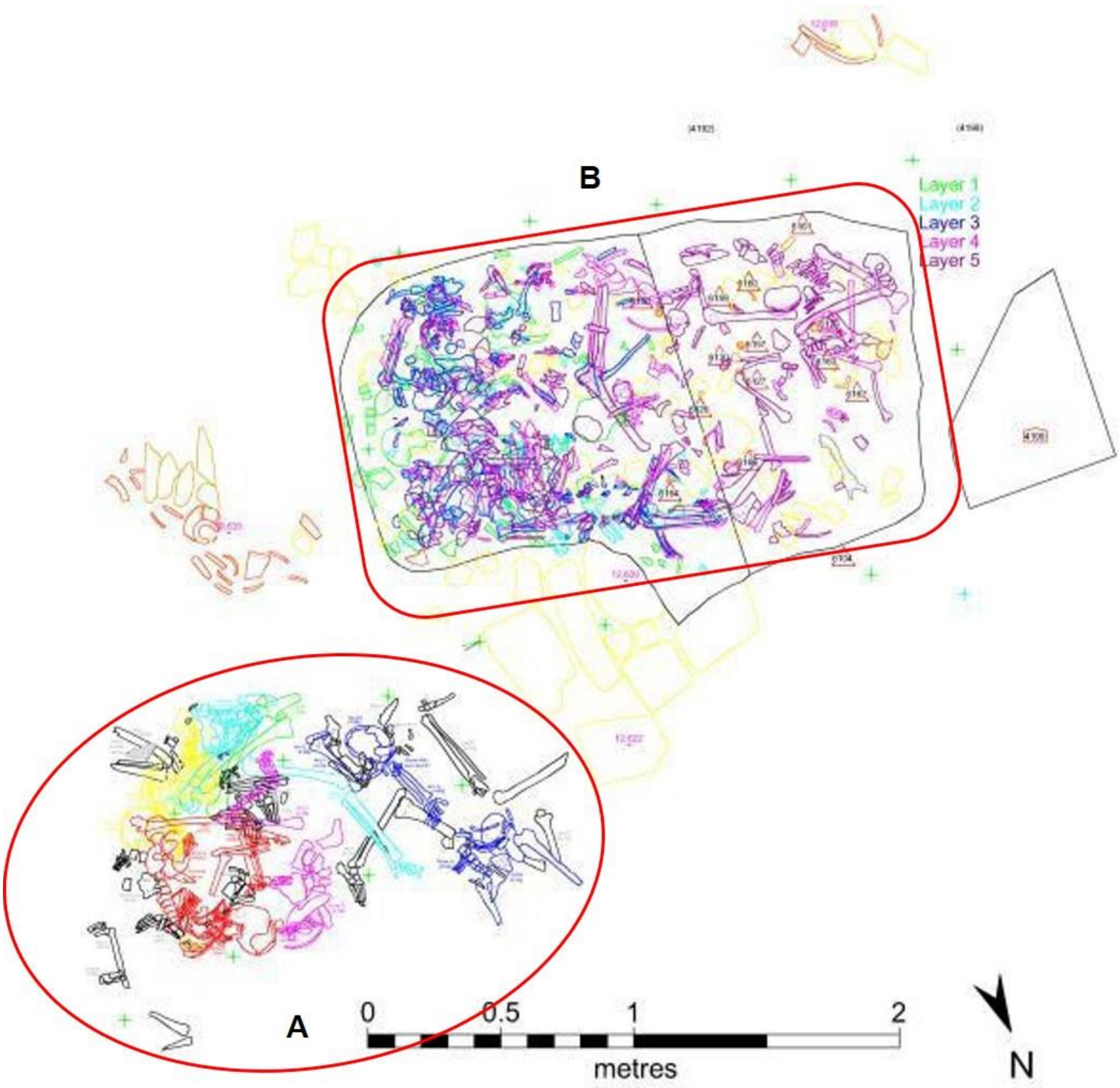

Figure 57: Digitised plan showing the relative positions of burial 101 (A) and burial 110 (B), with its rectilinear grave cut. Modified after image provided courtesy of Dr Claude Doumet-Serhal. Original image: M. Williams.

In general, preservation of the bone was fair to good, although it ranged from poor to very good. Following excavation and recovery, many of the individual skeletal elements were fragmentary. In addition, these remains were excavated over five to six years ago and, subsequently, they have been subject to a limited amount of post-excavation taphonomy.

Analyses were based on those remains present in the material sent from Lebanon and these data supersede preliminary data previously published in Collins (2012) and the unpublished field reports.

4.2 Methods

The biocultural model encompasses multiple lines of enquiry and the assessment of a broad variety of evidence types in order to investigate and evaluate social environments and the biological impacts of social change. This model explicitly emphasises interaction between humans and their broader social, cultural and physical environments (Armelagos, 2011). More recently the biocultural model has developed deeper roots within the consideration of the effects of social relations and in particular those of power relations, on human biology (Martin et al., 2012). In bioarchaeology, this is facilitated through the analysis of human remains as the direct evidence of biocultural agency.

This chapter describes the general methods used to analyse commingled remains for standard demographic data. For more information concerning the analysis of trauma, the reader is referred to Methods of Assessment. Anatomical terminology follows recommendations described by Knüsel (2014).

4.2.1 Commingled assemblages

Under normal conditions, bioarchaeological analysis commences at the individual level, with skeletons being assessed for a number of standard demographic facets through the estimation of age-at-death and the determination of sex where possible, in addition to standard measurements for the purposes of assessing stature and ancestry, followed by a pathological analysis which may range in scope.

Following the analysis of individuals, data from individuals are then collated to form populations, an essential process when applying the biocultural model. Populations may then be compared within and between sites and assessed for differences in patterning across time. Osterholtz states that commingled remains present a major challenge: the individual is typically no longer visible or distinguishable within the population (Osterholtz, 2015: 67). However, this is not necessarily always the case, and it is suggested here that the statement might be refined slightly to refer specifically to complete individuals. As can be seen with the Sidon crusader material under consideration, portions of individuals were able to be identified within both burials 101 and 110, allowing some insight into individualised experiences of trauma within the group. What has not been possible is to make appropriate comparisons between individuals, which are only represented by incomplete sets of articulated remains, which do not necessarily overlap in the regions of the bodies represented. Thus, with the Sidon remains, the analytical emphasis is by necessity focussed at the populational level.

Overall indicators of violence can be examined including rates of specific peri-mortem and antemortem trauma types. Taken together, the assemblage can therefore be analysed to investigate any patterns of trauma within the population. These results can then be compared against broadly contemporary comparative sites to examine differences or similarities which may, in turn, aid in the interpretation of the remains under immediate consideration.

Evidence of interpersonal and/or inter-group violence, as represented by skeletal trauma in past human populations, allows the opportunity to test hypotheses and challenge theories concerning conflict and violence. Furthermore, this evidence is not subject to the interpretive difficulties inherently present within historical records and ethnographic reports (Walker, 2001).

With this in mind and as a result of several questions regarding the timing of deposition and the identity (-ies) of the human remains, several key assumptions were treated as working hypotheses:

1. All individuals represented in burials 101 and 110 died in a closely contemporary context if not in a single event

2. All individuals belonged to the same social group (i.e. Christians resident in Sidon at the time of their deaths)

4.2.2 Levels of analysis

Individual skeletal elements form the simplest whole unit of analysis, with trends in the number (Minimum number of elements, hereafter MNE), demographic profile (where able to be determined), pathological status and robusticity of elements are assessed at the population level.

However, problems arise where commingled assemblages are also highly fragmented, potentially as a result of the manner of death but more likely attributable to one or a number of a broad spectrum of taphonomic factors affecting preservation or perhaps a combination of these. Once data for individual fragments and elements have been analysed, these individual data can then be collated into site-specific groups (e.g. Burials 101 and 110; or different body regions).

Of primary concern initially is the collection of baseline data concerning the demographic profile of the skeletal assemblage. This basic biological information includes individual profile characteristics such as age-at-death and sex, as well as group descriptors, most notably the minimum number of individuals represented (hereafter, MNI). These data are particularly important for commingled and fragmented assemblages where opportunities for the collection of other more specific data may be severely limited.

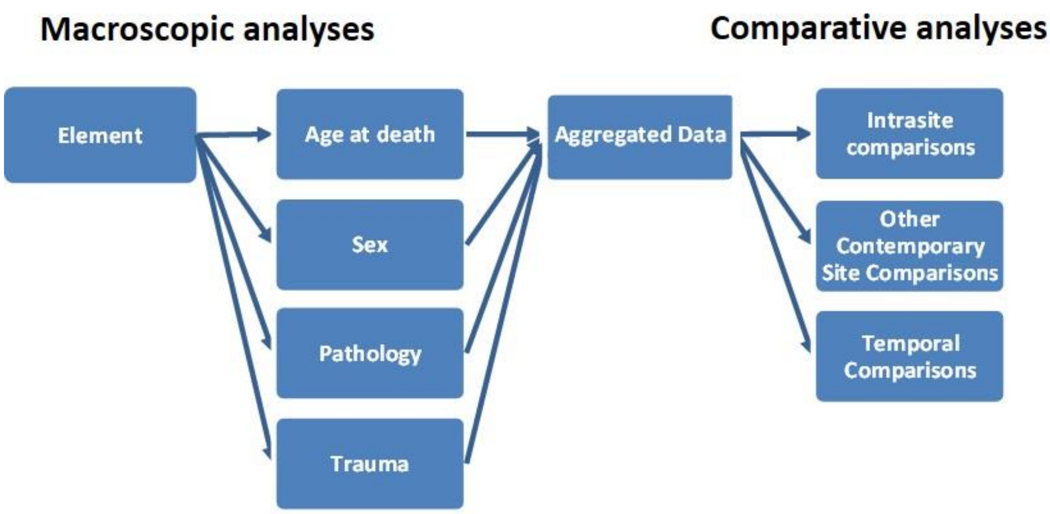

Figure 58: Flow chart detailing ideal process of analyses.

4.2.3 Minimum number of individuals (MNI)

Basic guidelines have been described for calculating the MNI represented in a skeletal assemblage, based on counts of individual elements and their relative completeness (Brothwell, 1981; Buikstra and Ubelaker, 1994; Waldron, 1994). Whilst perhaps more practical in time-constrained contexts, there are flaws in that larger long bones are divided into a small number of fairly large sections during recording (typically three diaphyseal sections and two epiphyseal sections). When dealing with commingled and fragmented assemblages the application of this method risks either conflation or inflation of the MNI depending on how it is applied to smaller fragments, which may be disregarded (potentially excluding individuals) or included (potentially leading to individuals being counted more than once).

Clearly, the more features or parts of a bone element one can identify, the greater chance of calculating a more accurate count and thus a more accurate MNI. Knüsel and Outram (2004) proposed a zonation method, which divided individual bone elements into a greater number of identifiable 'zones' which included specific morphological features. For each element, all zones are scored as either present or absent, with the minimum number of elements (MNE, here taken to represent the MNI) based on the zone or zones with thehighest count. Another variant on this method has also been developed recently (Mack et al., 2016), this time focussing on specific morphological landmarks of individual bone elements, rather than zones or regions of bone, providing an even higher resolution of the remains.

Table 4: Summary of potentially recordable data points for exemplar bone elements using different methods for determining MNE/MNI.

Bone Element	Number of Data points		
	Traditional method	Zonation method	Landmark method
Cranium	20	15	52
Scapula	2 (-4)	9	11
Humerus	5	11	15
Os coxae	3	12	12
Femur	5	11	13
Tibia	5	10	8
Calcaneus	1	5	5

For the purposes of this research, Knüsel and Outram's zonation method was chosen for its relative speed and ease of application and data management, whilst still retaining a good resolution for identification of fragments. In addition to the set of zones for the cranium outlined by Knüsel and Outram (2004: 93-95), a further two zones were also recorded, attributable to the separate petrous portions of the left and right temporal bones

Determination of the MNI involved a number of other phases of analysis necessary for potentially re-associating disarticulated materials and consolidating individual sets of remains and thus ensuring the MNI was not unduly inflated. These phases included sorting (by side; size/age) and pair matching (by size/age/morphology). All unfused elements or fragments were categorised as subadults.

Throughout this process of baseline data collection, given the rarity of such an assemblage and the need to preserve as much potential for information gathering as possible, the decision was taken to retain as much contextual information as possible for every fragment recovered during excavation. For the disarticulated whole elements and fragments, this involved a significant amount of time and effort maintaining separate bags for material from over eighty grid/layer contexts within burial 110 alone.

4.2.4 Demography

Where an individual's remains are incomplete, estimation of age-at-death and sex can also be less accurate and less precise, especially when specific regions of the skeleton are absent or in a poor state of preservation. For some individual elements, age and sex determination can be attempted in some cases (e.g. using metric analyses). However, these methods introduce additional error based on standard error rates and the use of different reference samples (used to develop the regression formulae involved) which may not be directly comparable to the population under consideration. Obviously, such metric analyses require certain aspects to be complete and uninterrupted (e.g. maximum length). The valid application of such methods is therefore clearly dependent upon the degree of fragmentation of remains and the presence of whole elements or whole parts of elements.

The complete distribution of trauma within a single individual cannot be analysed and thus the individual element necessarily becomes the unit of analysis rather than the individual. The emphasis on the element data in turn necessitates the use of population-level questions, consistent with Armelagos' (2011) biocultural model (see also Larsen, 1997; 2002).

4.2.4.1 Age at death estimation

When dealing with commingled and highly fragmented remains, together with the absence of sufficient skeletal markers known for age-related changes, estimation of adult age-at-death relies on a number of different observable traits in particular:

- General size of the element
- Completion of epiphyseal fusion

Standard techniques for estimating age-at-death such as the Suchey-Brooks method (Brooks and Suchey, 1990) and Lovejoy et al. (1985) were useful, but the number of complete or well-preserved elements/fragments that could be legitimately subjected to these methods was extremely limited. In addition, two other methods (Dudzik and Langley, 2015; Boldsen et al., 2002) were applied to estimate the age of pelvic bones and fragments in order to test for any differences in the results produced and to confirm the overall demographic profile for the group.

For postcranial material indicating subadult age, epiphyseal fusion was also taken into account, following diaphyseal closure rates reported in Schaefer et al. (2009). Osterholtz (2015: 72) notes that with commingled remains, subadults pose a particular problem concerning both their age estimation and estimation of the MNI. The issue arises as a result of the varying timing of epiphyseal union in different elements in an individual's skeleton. Consequently, where remains become disarticulated or dissociated, different elements from the same individual may potentially be mistaken as representing separate individuals.

Where commingled and fragmentary assemblages are considered, for the vast majority of isolated fragments, only an indication of whether the individual had reached skeletal maturity at the time of death or not is typically possible. Similarly, the determination of an individual's sex is not likely to be possible, except where such fragments represent sexually dimorphic elements and the relevant morphological traits are preserved and observable.

Specific pathological diagnoses may also be used to inform estimates of age-at-death, according to their reported clinical aetiology. For instance, the condition termed Diffuse idiopathic skeletal hyperostosis (DISH) is more commonly observed in males, with prevalence increasing with age (Ortner, 2003: 559), although studies also suggest an association with obesity and insulin-independent diabetes mellitus (Verlaan et al., 2007).

Table 21 summarises the estimated age data for those remains for which preservation of age markers permitted their assessment.

4.2.4.2 Sex determination

The main aim of the demographic analyses was to produce a simple demographic profile characterising the group of remains and their demography, with a detailed and reliable description of the age and sex groups present not possible without extensive DNA analyses.

Sex determination from cranial remains was attempted with articulated crania as well as with fragments where sufficient of the cranium was present to allow observation of at least one distinct dimorphic trait, following standard practice and remaining aware of the limitations (Acsádi and Nemeskéri, 1970; Buikstra and Ubelaker, 1994; Cox and Mays, 2000; Walker et al., 1988).

Despite the use of general size and standard analyses, sex was difficult to assess for the vast majority of elements and fragments. With regard to disarticulated elements which were unable to be re-associated with any other remains, it was decided only to attempt assessment of those sexually dimorphic elements and their fragments known to be reliable i.e. the pelvic bones. Specific sexually dimorphic traits examined followed those accepted within standard practice (Phenice, 1969; Powers, 2012).

Ordinarily, metrical analysis of skeletal elements would also be employed either to support/confirm the results of macroscopic assessment of sexually dimorphic traits or in the absence of the latter. However, with highly fragmented assemblages many skeletal elements are unlikely to retain their integrity and therefore the opportunities to take accurate and reliable measurements are extremely limited. Even so, some elements with potentially sexually dimorphic dimensions may still be represented well. The talus for example, has been shown to preserve well within commingled and fragmented assemblages, forming the basis of the MNI at Tell Abraq (Osterholtz et al., 2014a).

Wherever possible standard measurements were taken of major long bones and other elements, where the integrity of the relevant area of the bone had not been compromised.

Osterholtz et al. (2014a) argue that the application of metric analyses for the determination of sex is a valid approach for commingled remains (particularly where multiple methods are used, and consistency of results may be assessed). This may well be the case for prehistoric populations which we assume to be relatively homogenous in their make-up; yet, one is unlikely to be able to rely on consistent results of multiple methods when analysing a mixed population, such as that likely representing an urban population from one of the cities of the Frankish States (i.e. the Sidon material).

4.2.5 Trauma

Trauma can result from a wide variety of activities. The majority of these contexts can be broadly divided into two main groups: interpersonal (or inter-group) violence and accidental trauma. The patterning of trauma, including analysis of its distribution and location across the body, both in individuals and within groups or populations can aid in differentiating between intentional trauma and accidents (Brink et al., 1998) as well as between accidental trauma and subsistence-related patterns (Murphy et al., 2010). Thus, trauma patterns may be differentiated between separate social contexts based on occupational activity, climatic environment or social interactions, most notably competition either formalised as in a sporting context or in more lethal combat that typifies warfare. For example, modern interpersonal violence in an urban context has been characterised by a greater prevalence of cranial depression fractures and facial fracturing (i.e. blunt force) (Brink et al., 1998) as well as by the presence of rib fractures (Brickley and Smith, 2006). Similarly, Novak (2007) attributed the prevalence of injured limbs amongst a mass grave deposit of individuals associated with the Battle of Towton (1461 CE), to fighting styles and the intentional targeting of specific body regions which were less well-armoured than the torso. Again, within the Medieval context, Knüsel (2011) has also noted that the prevalence of specific antemortem trauma can suggest specific activities associated with warfare and military training of the period.

4.2.5.1 Identification and documentation of trauma

Identification and interpretation of possible traumatic lesions was undertaken using the application of techniques developed within the fields of forensic pathology and anthropology (Galloway, 1999b; Maples, 1986; Reichs, 1998; Spitz, 1993). Data collection was carried out in a similar manner to recording methods employed in modern forensic cases. These methods included re-fitting, textual/verbal description, visual illustration, photography, interpretation and where possible, sequencing of wounds (see Appendices 3-9). A pilot project to 3D model and reconstruct fitted fragments of a cranium using digital photogrammetry was also undertaken in order to assess the benefits of virtual reconstruction (see Appendix A15).

The vast majority of bone fragments and disarticulated elements were unable to be re-associated with specific individuals. This was also the case for articulated body parts, which for the most part lacked any continuity between any individual groups.

For the current study, the following traits were assessed as part of the macroscopic observations made of all potential traumatic lesions:

- Fracture type (where identifiable, e.g. butterfly; depression)
    - Fracture outline (e.g. linear/curvilinear/irregular)
    - Fracture surface
        - Cortical bone (e.g. smooth/roughened; irregular; ’polished’)
        - Trabecular bone (e.g. flat/irregular)
    - Fracture surface staining
        - Stained (i.e. old)
        - Unstained (recent post-mortem breakage)

4.2.5.2 Timing

The timing of lesions was assessed through the observation of specific characteristics. Antemortem changes were identified by the evidence of healing, specifically the presence of new bone and/or bone remodelling (Ortner, 2003; Sauer, 1998). With regard to old or well-healed injuries, features used to discern evidence of such changes included the presence of discontinuities in the bone surface morphology that could not otherwise be explained, the presence of remodelled new bone and/or associated characteristics such as focussed porosity.

4.2.6 Isotopic analyses

A programme of isotopic analyses was also undertaken with a view to characterising the human remains either as a homogenous group or as a mix of individuals and/or groups with varying isotopic signatures.

The human remains were sampled for strontium and oxygen isotopic analyses in order to investigate the potential geographic origins and mobility of individuals. Although the current lack of a detailed strontium baseline map for the region limits interpretation, it was felt that the analyses had good potential to distinguish between those who had been resident in the region long-term (locals) and those who were relative newcomers (non-locals). For details on the principles, methods and procedures, the reader is directed to Strontium and Oxygen Isotope Analyses.

The human remains were also sampled for carbon and nitrogen stable isotope data with a view to investigating crusader period diet and any potential dietary variation during lifetime. For details on the principles, methods and procedures, the reader is directed to Carbon and nitrogen isotope analyses.

Additional radiocarbon analyses were also carried out on selected samples of human bone from burials 101 and 110 in order to confirm and if possible, refine their dating. Regarding the sampling selection criteria and method, the reader is directed to Radiocarbon isotope analysis and dating.

Results of the macroscopic and isotopic analyses are presented in the following chapter. Results of the trauma analyses incorporate multiple case studies to describe and demonstrate the features and changes observed in the human remains, and to support their current interpretation. Some limited discussion of the individual case studies is also included. However, for fuller discussion of the human remains and their broader context, the reader is directed to Chapter 6.

5 RESULTS

5.1 Demography

5.1.1 Minimum number of individuals (MNI)

In the course of the re-fitting exercise, two matched sacral fragments between burials 101 and 110 were identified, indicating a strong probability the two deposits were closely contemporary, if not derived from the same event. It was therefore felt appropriate to consider the remains from the two deposits as a single group. Consequently, re-fitting and the sample selection process for the various isotopic and DNA analyses, resulted in the identification of a minimum number of 25 individuals represented by all remains from burials 101 and 110.

Although previous publications have reported postcranial long bones (femora and tibiae) to be most frequently represented in disarticulated materials, the MNI from burials 101 and 110 at Sidon was based on the number of individualised left petrous portions of the temporal bone. Though, clearly the remains include incomplete individuals, the cranial MNI is corroborated by the postcranial MNI (n = 21), based on the proximal right ulna. Consequently, this means the original field MNI (N = 15) has been significantly increased by an additional 66 percent.

Estimations of MNI based on postcranial elements are presented in APPENDIX A4: Postcranial MNI.

Once an appropriate database had been developed, the zonation method (Knüsel and Outram, 2004) proved highly effective for managing and interrogating the data following completion of data collection. It should be noted that recording of whole bones and bone fragments using the zonation method can also help to create a detailed record of the completeness/preservation of individual sets of remains and their elements, which can subsequently be used to more accurately assess loss over time and the impact of handling and changing curation strategies.

5.1.2 Age and sex

The majority of the remains appear to belong to adults, although at least two subadult individuals are represented, most likely adolescents based on the degree of epiphyseal fusion.

For the grouped commingled remains, age-at-death was estimated to range from 15.0 to 96.4 years. Evidence from the pubic symphysis indicated a maximum age-range of 15.0 – 96.4 years, based on point estimates following Boldsen et al. (2002). Evidence from the auricular surface produced a similarly wide range, with the youngest individual estimated to be 18.2 and the most elderly estimate 93.9 years, again based on point estimates following the transition analysis method (Boldsen et al., 2002). Evidence from traditional methods produced equally broad age ranges, with the group spanning from 30– 39 to 40 – 59 (Lovejoy et al., 1985) and 16 – 65 to 53 – 92 years (Buckberry and Chamberlain, 2002). The traditional method applied to the pubic symphysis (Brooks and Suchey, 1990) produced a similar age range for the group, with estimates spanning from 15 – 23 to 27 – 66 years.

In the context of studying such incomplete, highly fragmented and commingled remains, the Dudzik and Langley (2015) method appeared least useful in this instance, with evidence of all three age categories (i.e. age ranged from 18 – 40), although it does provide additional support for the presence of at least one subadult.

Macroscopic analysis of skeletal elements with sexually dimorphic traits indicate all observable elements of fragments of elements present male characteristics, with some presenting indeterminate characteristics. There was no clear evidence for the presence of females within the grouped assemblage, with none of the fragments with observable sexually dimorphic traits exhibiting definite female traits.

The reasons for this lack of success in re-fitting/re-associating individuals are likely due to a number of factors/causes. In 2009, with excavation of burial 110 limited to its eastern half by the overlying baulk to the west, groups of articulated elements may have been only partially recovered initially. Subsequent disturbance/breakage during re- covering and uncovering of the deposits once the baulk had been taken down in 2010 may have resulted in associated groups of bones/fragments from the two seasons remaining unrecognised. In addition, the large number of bones and groups of articulated remains deposited in a largely random manner, potentially resulted in smaller fragments settling amongst or descending through surrounding/underlying groups of bones representing other individuals.

In many cases, the peri-mortem injuries observed in the remains, many of which were likely inflicted in a violent conflict event, would have resulted in significant fragmentation of bone elements and the removal and loss of whole sections of bone(/s). While soft tissue may have helped retain such transected fragments (as with the right acromion process of context 4247), in cases where remains were subsequently left exposed for longer or otherwise underwent more advanced decomposition, such fragments are likely to have been lost. Evidence for the differential taphonomic conditions to which the remains were subject is clear when comparing the relatively well-preserved remains of context 4247 to the weathering evident on the fitted fragments of an adult right femur recovered from separate ends of the grave pit, indicating the weathering must have occurred prior to deposition within the pit.

During analyses of the articulated groups of remains, attempts were made to match any disarticulated elements or fragments which lacked any associations and to consolidate individuals. Reconstructions of crania were also attempted, but again were limited by the high degree of fragmentation and incompleteness of individualised remains. The high degree of fragmentation of individual bone elements, most notably within burial 110, introduced a number of challenges/issues, not least of which was the estimation of a reliable MNI. This inevitably introduces problems influencing the management of trauma data, specifically the calculation of trauma prevalence within the material under consideration. The issue of MNI calculation was approached through the application of the ‘zonation’ method (Knüsel and Outram, 2004) which takes account of the typical areas of different individual bone elements likely to be preserved as discrete fragments. Implementation of the ‘zonation’ method permitted a more reliable calculation of true prevalence than traditional MNI methods. Such traditional methods (see Buikstra and Ubelaker, 1994: page 8 and attachment Ch2.1) typically only count larger sections of long bones and consequently, smaller fragments, potentially representing additional individuals, may be excluded (leading to an underestimation of the MNI); or alternatively if included, they may produce an inflated MNI if they derive from the same element.

5.2 Peri-mortem Trauma

5.2.1 Summary

There is substantial evidence for both peri-mortem sharp force and peri-mortem blunt force trauma evident in the skeletal remains from burials 101 and 110. Indeed, so far as the preservation of the material allows, it is clear that a minimum of seven individuals

sustained multiple peri-mortem traumata. In several cases (e.g. contexts 4147, 4247, 4304) individuals suffered more than one sharp force injury. This provides strong evidence to support the interpretation that the remains from burials 101 and 110 represent a group of individuals who died within a single violent event.

The general pattern of the identified confirmed sharp force traumata suggests a focus on the head, neck and shoulders (see Figure 59 and Figure 60). Regarding direction and side, the patterning of traumata is somewhat variable, yet never-the-less indicates a slight focus on the right side, with posterior injuries clearly demonstrating greater prevalence relative to anterior wounds. More specifically, the sharp force trauma of the cervical region indicates a defined focus on the posterior of the neck, possibly on the posterior right side, although this is based mainly on the high number of traumata observed in a single individual (4247).

In one individual (4247), there is evidence of two different classes of blade producing sharp force injuries which have impacted the surviving skeletal material. Despite many of the sharp force injuries being incomplete (i.e. with only part of the skeletal injury preserved and observable), in the majority of cases a heavy blade was indicated. The one striking exception to this trend was a very thin (< 1mm wide) deep, sharp force cut to the posterior aspect of a left femoral head belonging to an articulated left hip and thigh from burial 101 (4169_LegG).

Overall, the total number of fragments/elements exhibiting evidence of definite peri-mortem trauma was one hundred. This equates to an average of four elements per individual (100/25). Table 5 outlines the numbers of elements affected by different types of peri-mortem trauma, with cumulative totals based on the certainty of trauma identification/classification.

Table 5: Cumulative totals for minimum number of elements affected by peri-mortem trauma, by degree of certainty.

	No. of skeletal elements affected			
Degree of Certainty	All trauma types	Sharp force (SFT)	Blunt force (BFT)	Penetrating force (PFT)
Definite	100	62	35	5
Definite + Probable	398	190	212	37
All Possibles	762	368	405	78

Henceforth, only data pertaining to definite traumata, where confidence in trauma identification was deemed either high or unequivocal, is discussed.

Concerning the numbers of peri-mortem lesions (rather than individual bone elements affected), identifications of sharp force injuries were most prevalent, with cuts almost doubling the number of blunt force traumata. However, the figure for the latter should be viewed as conservative, given the difficulty in identifying definite blunt force impacts attributable to interpersonal violence; the data for probable and all possible instances of blunt force (Table 5) supports the possibility that such injuries may have been equal to or exceeded the levels of sharp force. In contrast, there was very little reliable evidence of either projectile or defined penetrating injuries. Table 6 summarise the relative numbers and proportions of the different trauma types observed within the Sidon crusader remains.

Table 6: Burials 101 and 110 from Sidon, Peri-mortem trauma lesions by trauma type.
N.B. Total number does not match that in table above as two elements exhibited two different types of trauma.

Force	Number	Percent
Sharp	64	54.2
Blunt	48	40.7
Projectile/Penetrating	6	5.1
Total	118	100

Table 7: Peri-mortem trauma lesions of the cranium and mandible by trauma type.

Force	Number	Percent
Sharp	7	21.9
Blunt	22	68.7
Projectile/Penetrating	3	9.4
Total	32	100

Table 8: Postcranial peri-mortem trauma lesions by trauma type, comparable with Towton data (see Novak, 2007: 93, table 8.2).

Force	Number	Percent
Sharp	57	66.3
Blunt	26	30.2
Projectile/Penetrating	3	3.5
Total	86	100

5.2.2 Distribution

In general, the region of the body most impacted by peri-mortem trauma was the neck with a total of twenty-four fragments/elements observed to demonstrate traumatic changes, all of which involved sharp force lesions. In descending number of fragments/elements affected, the head (including the mandible) was second with a total of eighteen, followed by the thighs (12) and the hands (11), the torso (10) and the shoulders and upper limbs (each with 9). The lower extremities demonstrated least evidence for peri-mortem trauma with six elements of the lower legs affected and only a single instance amongst the feet.

Table 9: Total numbers of elements affected by definite peri-mortem trauma, by region.

Body region	N = 100	**Crude Prevalence (%, MNI = 25)**					
	Total No.	SFT (No.)	SFT (%)	BFT (No.)	BFT (%)	PFT (No.)	PFT (%)
Head	17	5	20.0	11	44.0	3	12.0
Neck	24	24	96.0	0	0.0	0	0.0
Shoulders	9	6	24.0	3	12.0	0	0.0
Upper limbs	9	6	24.0	3	12.0	0	0.0
Hands	11	10	40.0	1	4.0	0	0.0
Torso	10	6	24.0	4	16.0	0	0.0
Hips	1	0	0.0	1	4.0	0	0.0
Thighs	12	5	20.0	6	24.0	1	4.0
Legs	6	0	0.0	5	20.0	1	4.0
Feet	1	0	0.0	1	4.0	0	0.0

It should be noted the hands (and feet) are in all likelihood over-represented, particularly with regard to crude prevalence. They include a large number of separate elements, and any single injury to a hand (or foot) is likely to impact multiple elements (as is the case with the sharp force cut to the back of the wrist of limb/extremity 4168 which impacted a minimum of four elements).

If probable cases of peri-mortem trauma are included, the total number of identified fragments/elements for all three types of trauma rises significantly. Incidence of sharp force rises by a factor of three (n = 190), whilst both blunt force (BFT) and projectile/penetrative trauma (PFT) increase considerably more, with BFT rising by at least a factor of six (n = 212) and PFT by well over a factor of seven (n = 37).

Table 10: Total numbers of elements affected by either definite or probable peri-mortem trauma or both, by region.

Body region	N = 398	**Crude Prevalence (%, MNI = 25)**					
	Total No.	SFT (No.)	SFT (%)	BFT (No.)	BFT (%)	PFT (No.)	PFT (%)
Head	56	20	80.0	38	152.0	7	28.0
Neck	31	29	116.0*	2	8.0	0	0.0
Shoulders	31	16	64.0	20	80.0	4	16.0
Upper limbs	54	25	100.0	31	124.0	2	8.0
Hands	55	36	144.0*	14	56.0	5	20.0
Torso	36	16	64.0	18	72.0	2	8.0
Hips	15	1	4.0	13	52.0	1	4.0
Thighs	35	14	56.0	24	96.0	5	20.0
Legs	39	10	40.0	31	124.0	7	28.0
Feet	33	17	68.0	16	64.0	4	16.0
Unidentified	13	8	32.0	5	20.0	0	0.0

*Crude prevalences in excess of 100% are indicative of individuals with multiple wounds.

It is therefore suggested that when analysing complex commingled and/or disarticulated assemblages with high levels of fragmentation, identification of sharp force trauma, whilst still problematic, is more straightforward than identification of blunt force and projectile or penetrative trauma. As a qualification, however, it should be noted that some taphonomic processes have the potential to produce similar fracture characteristics to sharp force trauma (e.g. Oliver et al., 1989). In the current study, the author noted that where bones had burned in a low oxygen environment, with reduction producing charred black skeletal remains which are extremely brittle, post-mortem breakage can produce very clean, flat fracture surfaces with sharp fracture margins. Such taphonomic alteration can be difficult to distinguish macroscopically from real sharp force trauma lesions which have fully penetrated skeletal elements.

N.B. See APPENDIX A6: Peri-mortem Trauma Prevalence for additional data concerning numbers of elements by region representing all possible trauma observed.

5.2.3 Siding

Including all definite cranial and postcranial peri-mortem lesions, a side difference was observed in the sample following interpretation of individual injuries, with a greater prevalence of injuries impacting the right side, relative to the left. There was also an anterior/posterior difference observed with posterior injuries over 116% (N = 118) more prevalent than anterior injuries.

Table 11: Laterality of interpreted peri-mortem injuries (N = 118 for both sets of data).

Left		Right		Anterior		Posterior		Lateral	
No.	%	No.	%	No.	%	No.	%	No.	%
38	32.2	51	43.2	18	15.3	39	33.1	7	5.9

Table 12: Laterality of interpreted cranial peri-mortem injuries (N = 32 for both sets of data).

Left		Right		Anterior		Posterior		Lateral	
No.	%	No.	%	No.	%	No.	%	No.	%
11	34.1	15	46.9	13	40.6	10	31.3	5	15.6

Table 13: Laterality of interpreted postcranial peri-mortem injuries (N = 84 for both sets of data).

Left		Right		Anterior		Posterior		Lateral	
No.	%	No.	%	No.	%	No.	%	No.	%
29	34.5	37	44.0	6	7.1	30	35.7	2	2.4

5.2.4 Cranial trauma

A minimum of nine individuals presented evidence of peri-mortem cranial trauma. Only two individuals were observed to exhibit clear and unequivocal evidence of peri-mortem sharp force trauma to the cranial vault (4247 and 4301). In both these cases, heavy cuts had been inflicted on the right side of the head, with a posterior/lateral focus; 4247 also exhibited a classic 'scoop' lesion to the superior posterior aspect of the left side of the head (see Figure 64 and Figure 65). Alongside these two cases, three mandibles presented peri-mortem sharp force cuts (see Figure 97A and Figure 115-Figure 116 and Figure 119A), all focussed on the right side, with one also exhibiting evidence of a sharp force traumatic lesion to the left ramus, albeit of slightly less certainty regarding their timing/nature (Figure 118).

In general, the cranial material presented strong evidence for several individuals having been subjected to blunt force trauma in the peri-mortem time frame (see Figure 111 and Figure 117). Typically, this evidence consisted of one or more characteristics attributable to the mechanical properties bone retains within the peri-mortem period such as plastic deformation, incomplete fractures, depression fractures or crushing, hinged or retained fragments, smooth fracture surface texture, bevelled fracture surface angle, stained fracture surfaces, associated spalling or 'bone tear' and well-defined fracture edges. Remains representing a minimum of seven crania exhibited blunt force trauma of the cranial vault, with at least six of these individuals presenting evidence suggestive of two or more blunt impacts to the head.

Evidence of penetrating force or projectile injuries to the head was present but minimal, with one parietal exhibiting evidence of a partially healed (i.e. antemortem) penetrating lesion (see Section 5.6), and a probable peri-mortem example in one other individual (see Figure 112). The latter, context 4304, exhibits a slightly trapezoidal, almost square perforation penetrating completely through both inner and outer tables of the cranium, just lateral of the sagittal suture and superior to lambda, with probable slight evidence of internal spalling, although there is some slight post-mortem breakage also evident. This lesion is somewhat similar to some of the lesions observed in the Towton assemblage (e.g. Towton 9, see Novak, 2007: 99, fig. 8.11; also Figure 24), although it is smaller, measuring maximum external dimensions of 7.5 mm and 80 mm and internal maximum dimensions measuring 6.9 mm and 7.4 mm. It is feasible this lesion may have resulted from a narrow, pointed or single-spiked object penetrating down through the top of the head.

5.2.5 Postcranial trauma

A total of eighty-two postcranial elements presented evidence of peri-mortem trauma, with sharp force involvement in fifty-eight of these. In some cases, multiple elements had been impacted by the same injury, such as with the wrist belonging to 4168_ArmF. Sharp force injuries were most commonly observed in the vertebrae of the neck (e.g. Context 4247, section 5.3.3; Context 4147, section 5.4.3; see also Figure 119B and Figure 120A-B), and a minimum of four individuals exhibited sharp force cuts to the mid-cervical region. Amongst the post-cervical skeleton, both sharp and blunt force injuries were observed, in addition to some limited evidence of projectile or penetrating force injuries.

A single subadult individual exhibited evidence of multiple cuts to the left upper limb including sharp force evidence to the posterior aspect of the left ulna, whilst two other individuals had cuts to the right humerus, and one individual exhibited a cut to the posterior right ulna. A minimum of three individuals exhibiting cuts to the right hand are attested, based on their associated remains.

Very little evidence of peri-mortem trauma was observed in the thorax. Although examples of probable or possible peri-mortem modifications were observed in the fragmentary rib material from burials 101 and 110, only four of these presented strong evidence of peri-mortem timing. Only a single, unsided rib fragment exhibited strong evidence of sharp force trauma, whilst blunt force was attributed in three other rib fragments, two left and one unsided. Two individuals had sustained serious peri-mortem injuries of the lower vertebral column and back. The first, context 4147, exhibited strong evidence of a heavy transverse sharp force cut across the neural arch of the ninth thoracic vertebra (see Figure 78C). The second individual, represented by the almost complete, articulated vertebral column known as context 4259, had sustained a massive oblique sharp force cut down across the posterior left lower back (see Figure 60 and Figure 97B). This injury had penetrated deeply enough to section at least three lumbar vertebrae.

Two individuals had suffered cuts to the left femur (see Figure 96A-C and Figure 97C) and a minimum of two individuals had suffered cuts to the right femur. However, no clear evidence of peri-mortem sharp force cuts was observed in either the legs (i.e. the tibiae and fibulae) or the feet.

Peri-mortem blunt force lesions demonstrated a broad distribution across the post- cervical skeleton, with the only exception being the left upper limb, although there was one potential blunt force impact to the proximal humerus of 4247. In most cases, blunt force lesions represented direct trauma; indirect trauma was also suggested but was difficult to infer and/or interpret due to the highly fragmented and incomplete nature of the remains.

Several possible penetrating injuries of the postcranial skeleton were observed, possibly representing either projectile injuries or stab/thrust-directed injuries with either bladed or pointed weapons. At least two elements, one left femur and one left tibia, exhibited evidence of penetrating injuries that may represent either stabs/thrusts from close-quarter weapons or projectile injuries. The femoral injury (see Figure 122A) was exceptionally well-preserved, with a well-defined, sub- trapezoidal-shaped and deeply penetrating lesion (max. 7.1 x 4.3mm) to the inferior posterior aspect of the greater trochanter. This lesion lay within an associated larger area of depression, with hinged/retained fragments of cortical and associated incomplete radiating fractures proceeding medially across intertrochanteric region.

Figure 59 and Figure 60 illustrate the distribution of all definite peri-mortem traumata across the whole skeleton observed on the human skeletal remains from burials 101 and 110.

N.B. Figure 109 and Figure 110 demonstrate the distribution of all definite <u>and probable</u> peri-mortem traumata for comparison.

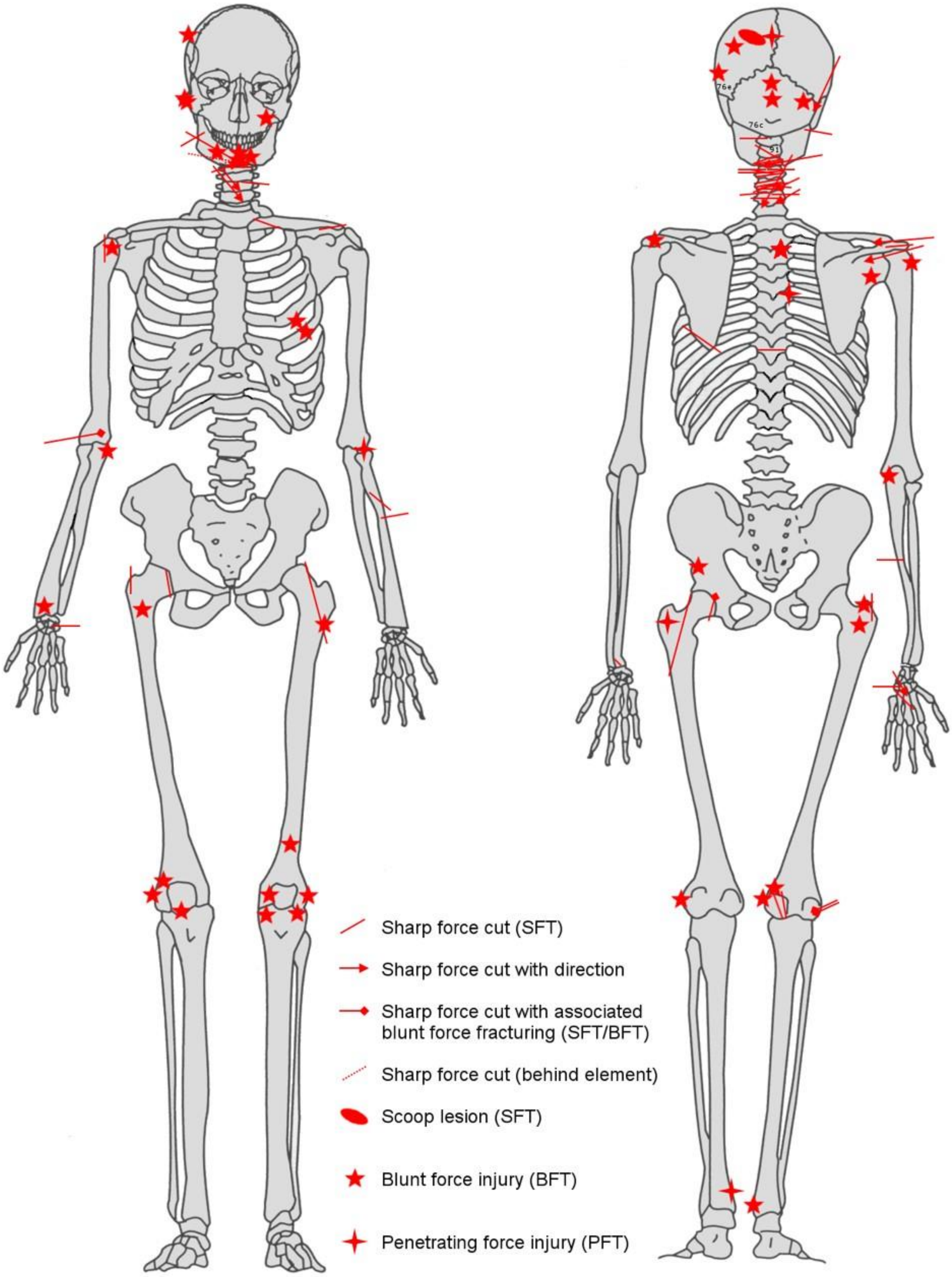

Figure 59: Distribution of all definite peri-mortem traumata (high confidence = red) across anterior (left) and posterior (right) aspects of skeleton.

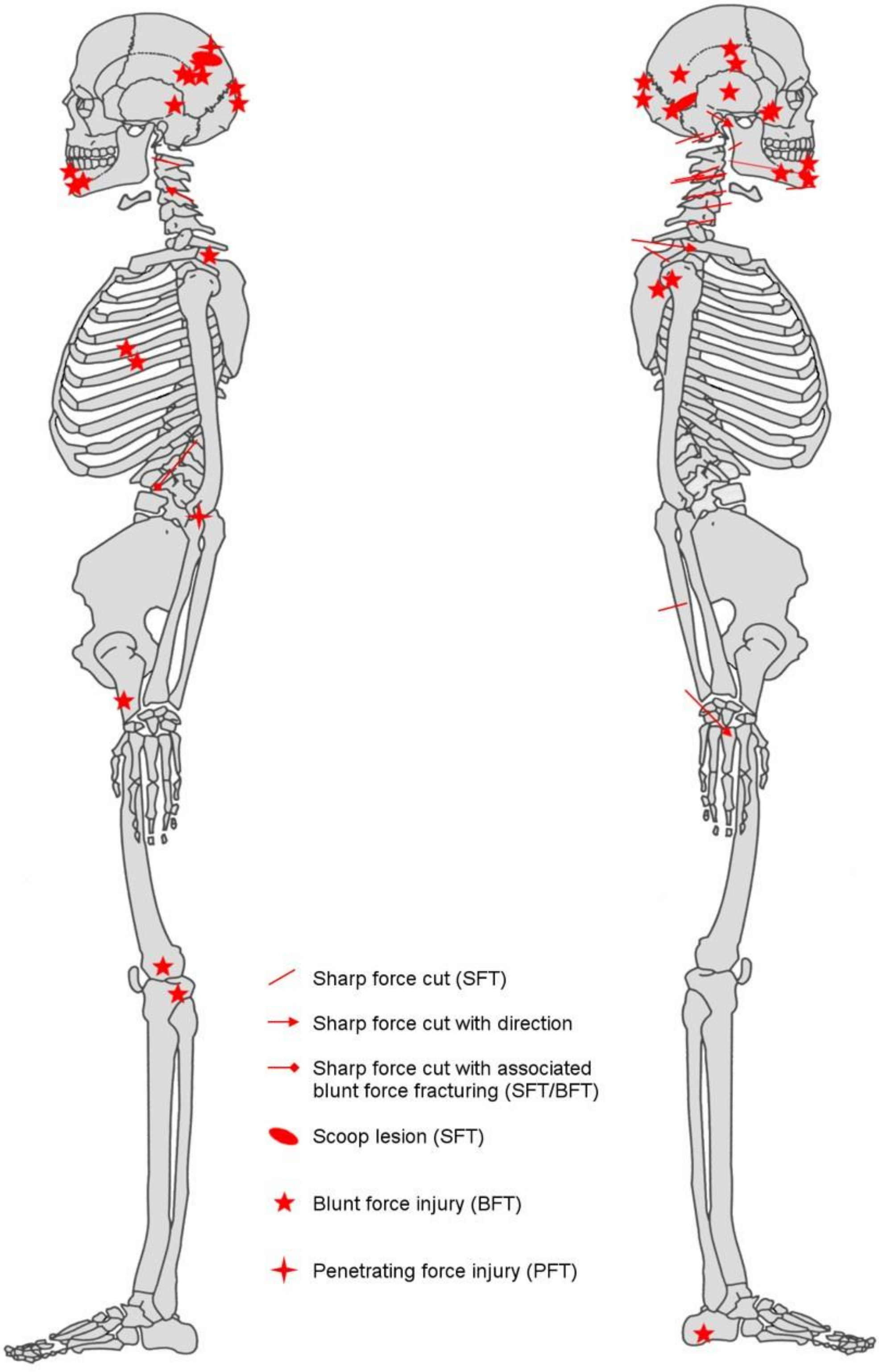

Figure 60: Distribution of all definite peri-mortem traumata (high confidence = red) across left (left) and right (right) aspects of skeleton.

5.3 Case Study 1: Context 4247

5.3.1 Summary

One of the most complete sets of articulated remains representing a single individual was represented by contexts 4246, 4247 and 4269 (context 4247 hereafter). This individual constitutes an appropriate case study for investigating both the number and patterning of traumata. Representing an adult of male sex (confirmed by DNA analysis, see Haber et al. (2019)), this individual's remains consisted of the majority of the cranium, neck, upper torso, shoulders and humeri and lay articulated *in situ* in the southeast corner of the grave cut of burial 110 (Figure 61 and Figure 62). The cranium, although not complete, could be at least partially reconstructed which facilitated observation and interpretation of several of the peri-mortem lesions. These fragments also became the subject of a digital 3D photogrammetry pilot study, with the creation of a digital 3D model and presentation (see Appendix A15).

Figure 61: Burial 110 – Mid-excavation photograph showing the skeletal remains representing context 4247 in situ, lying within the south-east corner of the cut close to the base of the pit.

Including both blunt force and sharp force traumata, the individual had suffered a minimum of twelve confirmed peri-mortem injuries with a minimum of sixteen skeletal elements involved.

Wounds resulting from sharp force trauma were present on both cranial and postcranial elements, with multiple injuries of the former including both penetrating and non-penetrating trauma. In total these blade injuries constituted a minimum of ten sharp force cuts, including two cranial injuries, a minimum of five cuts to the individual's neck and a minimum of two cuts to the right shoulder and one to the left shoulder. Possible evidence for a further four sharp force injuries was also observed, and these are also described below. Blunt force trauma was also in evidence to the posterior lateral left and anterior lateral right aspects of the cranium.

Of those cranial elements directly impacted by peri-mortem trauma, the left parietal, right parietal, right temporal and occipital were impacted by sharp force lesions; with those elements exhibiting evidence of blunt force trauma, including the frontal, left parietal, left temporal, occipital, right parietal, right temporal and right zygomatic.

Regarding the postcranial elements affected, the neck exhibited significant multiple sharp force traumata with involvement of the majority of the cervical vertebrae (C3-C7). In addition, sharp force cuts were evidenced on the right scapula, the right clavicle, the right humerus and the left scapula. Definite evidence of peri-mortem blunt force trauma (i.e. representing high confidence in timing) was only observed in the T3 vertebra. However, by association multiple other thoracic vertebrae (T2-T5) exhibit evidence of probable blunt force trauma (moderate confidence) also, as does the left scapula which exhibits multiple instances of such.

In addition, this individual exhibited a probable well-healed antemortem fracture to the spinous process of the T6 vertebra, indicative of blunt force trauma earlier in the individual's life as well as partial fusion of the T3 and T4 vertebrae, possibly attributable to the same antemortem blunt force injury.

Figure 63 shows the distribution of all definite and probable perimortem trauma across the extant skeleton known as context 4247.

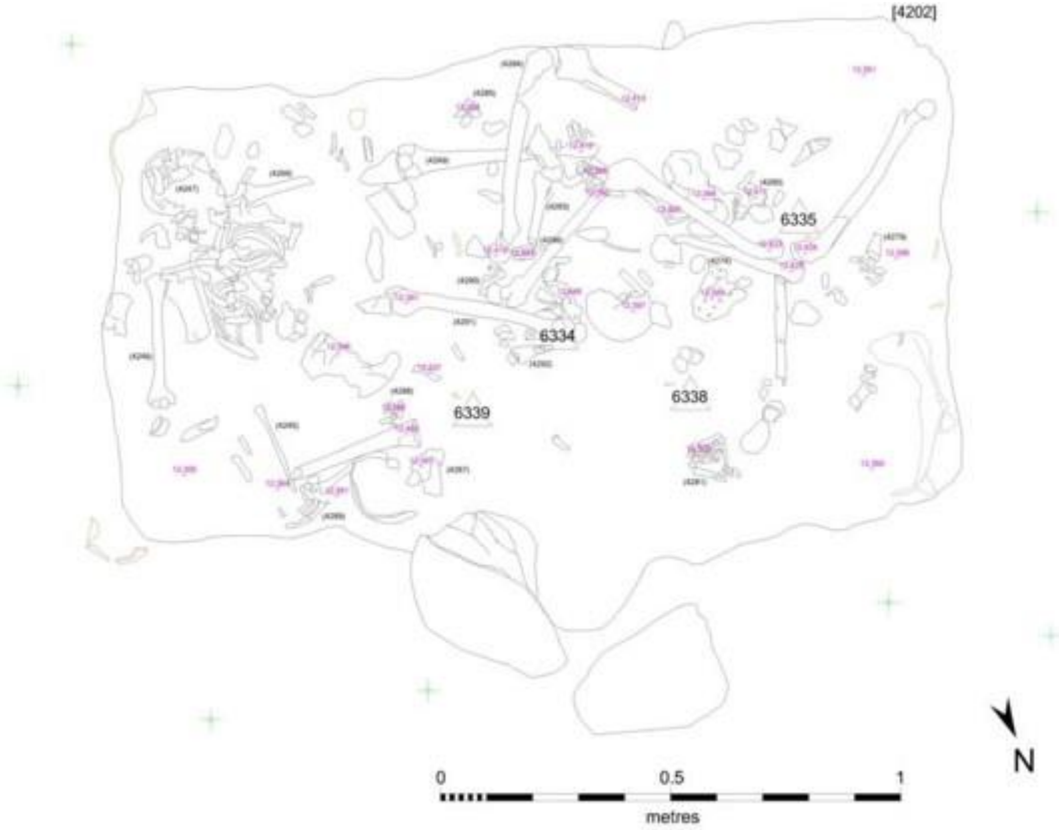

Figure 62: Plan drawing showing remains relative to other skeletal material at the same level within the pit. Modified after image provided courtesy of Dr C. Doumet-Serhal. Original image: M. Williams.

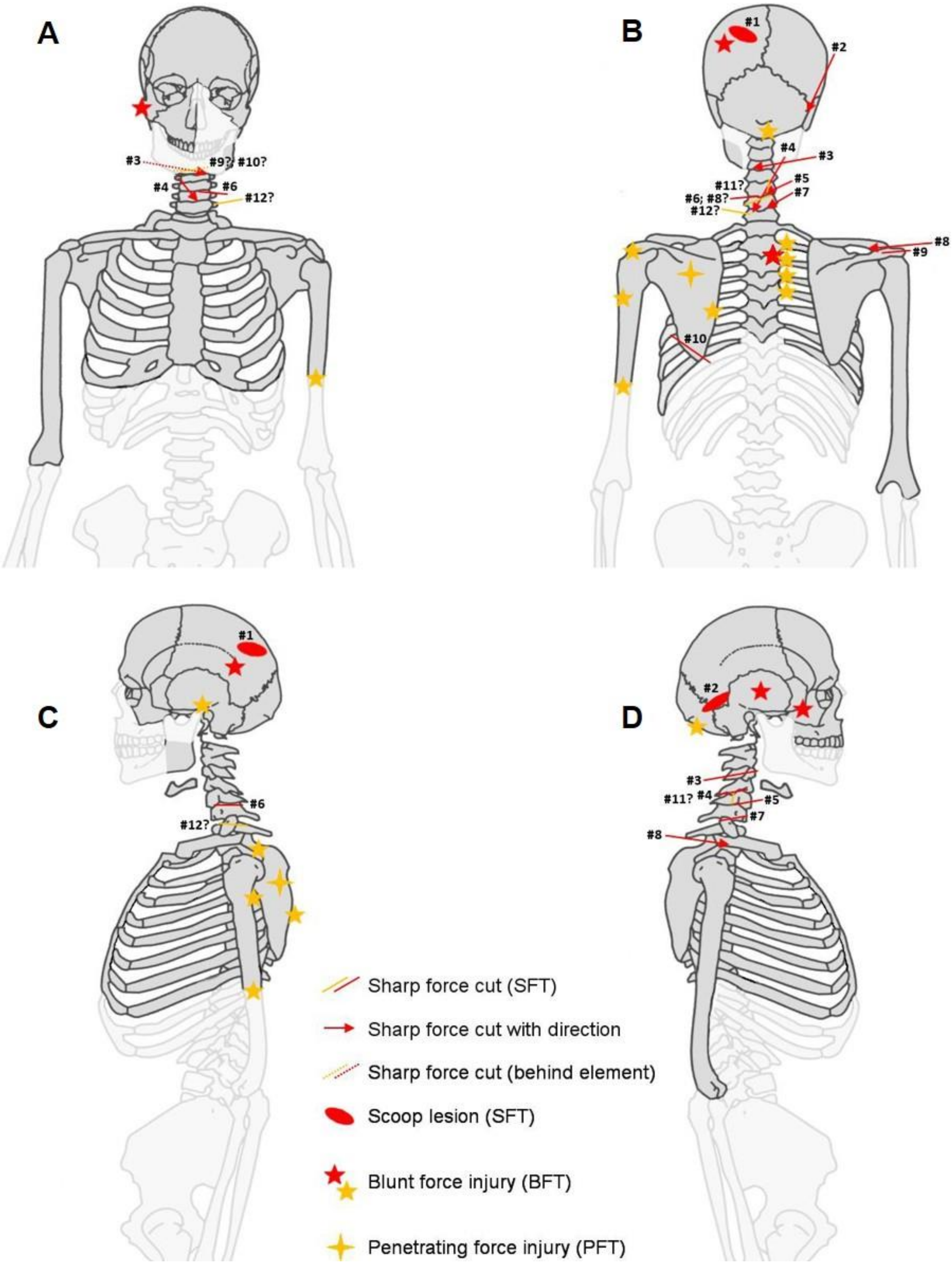

Figure 63: Context 4247 - Distribution of all peri-mortem traumata (high (red) and moderate (yellow) confidence) across extant skeleton: A) Anterior view; B) Posterior view; C) Lateral left view; D) Lateral right view. Full descriptions of the individual traumata follow.

5.3.2 Context 4247: Cranial trauma

A minimum of two distinct blade wounds were observed on the cranium. The first of these (cut #1) is a long-edged, shallow oblique cut to the centre of the left parietal (measuring at least 50.3 mm long and with a maximum width of 23.4 mm wide), resulting in a wide ‘scoop’ lesion to the ectocranial surface penetrating the outer table and exposing the diplöe (Figure 64 and Figure 65). The lesion does not appear to have interrupted the inner table, although this is not certain as there has been some slight post-mortem breakage of the fragile inner table since excavation and recovery. This lesion traverses two large fitted cranial fragments, and it is assumed to predate the fracture separating the two fragments. However, it is difficult to be certain whether the fracture which crosses the sharp force lesion may have occurred at a similar time or, in fact, represents post-mortem breakage.

At the time of excavation and initial field assessment, the exposed diplöe was complete, although there was evidence of a possible radiating fracture and/or slight penetrating lesion close to the midline of the posterior margin of the cut. Assuming cut #1 did not penetrate fully, it is doubtful this wound would have been fatal, especially if the individual received treatment; although the possibility of associated complications from such a blow (e.g. concussion) should not be discounted. However, the individual’s other peri-mortem injuries most likely preclude the latter.

Figure 64: Context 4247, Superior view of extant fitted cranial fragments, showing peri-mortem sharp force cut partially penetrating the centre of the left parietal (outer table and diplöe only), resulting in a broad, 'scoop' lesion (cut #1).

Figure 65: Context 4247 – Detail of cut #1, showing sharp posterior fracture margin of 'scoop' lesion and more irregular anterior side of lesion, indicating the direction of the blade strike. Note the small, incomplete fracture (white arrow) evident to the posterior lateral broken edge of the posterior parietal fragment, indicating peri-mortem blunt force to this region also (see Figure 63B-C also). N.B. The perforation at the centre of cut #1 is the result of post-mortem breakage.

A second confirmed blade injury (cut #2) constituted a much deeper cut on the posterior lateral right parietal in the region of asterion and the parietal notch (Figure 66 and Figure 67). This injury fully penetrated one of the thickest parts of the cranium. Only the superior aspect of the fracture and the region impacted by the injury was recovered, with the fitted fragments of the extant surface suggesting an anterior-posterior aligned minimum length of 55.8 mm and a minimum width of 18.7 mm. This section of the right parietal, immediately superior to the mastoid region, exhibited a highly polished cortical surface, the cut having essentially sectioned the bone at an oblique angle. Such an injury is likely to have resulted in significant trauma to the (posterior right side of the) brain, certainly incapacitating the individual and most probably would have resulted in death, especially if left untreated.

Figure 66: Context 4247, View of extant posterior right cranium showing peri-mortem sharp force cut #2, constituting a massively deforming cranial vault blow fully penetrating the asterionic region, and resulting in associated radiating fractures.

Figure 67: Context 4247, Detail of cut #2, showing sharp superior fracture edge and superior smooth wall in contrast to rougher texture of extant inferior fracture surface (white arrow).

Evidence of blunt force injury of the posterior left side of the head was exhibited in the form of an irregular depression to the central area of the left parietal with associated incomplete radiating fractures (see Figure 66 for evidence of the latter). The anterior lateral right side of the cranium also exhibited strong evidence of blunt force trauma. The extant fragment of the right temporal, consisting of the inferior squamous portion and lateral aspect of the right temporomandibular joint, exhibited a curvilinear fracture outline with a smooth, stained fracture surface, along with evidence of a breakaway spall or 'bone tear' (also known as 'peeling') at the interior margin. It is possible such a lesion may have been secondary to the heavy sharp force cut which penetrated the parietal notch region at an oblique angle, but this cannot be confirmed.

The extant right zygomatic also exhibits a quite linear, almost vertical complete fracture that effectively bisects the body of the element, with the lateral/posterior half missing. The fracture surface is stained, and it is likely this represents a heavy peri-mortem blow to the anterior right side of the head/right cheek.

Furthermore, additional evidence for potential blunt force injuries to the head was also observed. The extant fragment of the left temporomandibular joint (including the anterior aspect of the temporomandibular joint and the root of the left zygoma) exhibited stained fracture surfaces, with the broken zygomatic root exhibiting a curvilinear fracture outline indicating breakage occurred in the peri-mortem timeframe, potentially representing a blow to the left side of the head.

There is also an incomplete, radiating fracture across the endocranial surface of the lateral 'neck' of the right occipital condyle, along with other general peri-mortem indicators of the inferior occipital (stained fracture surfaces and relatively smooth/curved fracture outlines). It is possible these last represent secondary fractures associated with the peri-mortem blunt force blow indicated to the superior/posterior left side of the head or indeed the suggested blow to the anterior right side.

5.3.2.1 Additional cranial observations

At the time of initial processing, following excavation and recovery in 2010, the extant cranium exhibited a series of what appeared to be four similar penetrating lesions lying relatively equally spaced across the posterior lateral aspect of the left parietal. Unfortunately, little evidence now remains of the majority of these lesions, with only a single lesion still discernible with any confidence.

Figure 68, a photograph taken at the time of initial assessment in 2010, shows this lesion slightly penetrated the inner table in the same area as the posterior lateral margin of cut #1. The 2010 image shows the inner table largely intact prior to the slight post-mortem breakage seen in Figure 64 and Figure 65 above. However, it is clear there was at least one incomplete radiating fracture radiating antero-medially away from the anterior-most penetrating lesion (Figure 68, white arrow), with a second possible radiating fracture extending laterally and now forming part of the complete fracture separating the two large cranial fragments.

Of note, was a plaque-like deposit just posterior of cut #1 and the penetrating lesion which was still evident at the time of laboratory analysis in 2018. It is possible the two central lesions observed in 2010 may have only very slightly penetrated this deposit, which subsequently deteriorated resulting in their loss. The posterior-most lesion observed in 2010 may, in fact, be a natural artefact created by the superior aspect of the left lambdoid suture. What is curious and difficult to explain is the relatively equal distance between the four lesions and their comparative similarity, as demonstrated in the 2010 image.

It is postulated that these lesions could represent evidence of a multi-pointed object rolling in an arc across the superior aspect of the posterior left side of the head of the individual.

Figure 68: Context 4247 – Superior oblique view of posterior left parietal, showing possible peri-mortem penetrating traumata observed during initial assessment (black arrows), now unobservable. Only a single, possible penetrating lesion is still evident (white arrow): Note the association of at least one incomplete fracture in this image. The white-coloured plaque-like deposit is also visible in direct association with the two middle penetrating traumata.

5.3.3 Context 4247: Cervical trauma

During excavation and recovery, it was clear that context 4247 had suffered a heavy sharp force cut in the region of the neck/throat, with the transected fragments of an upper cervical vertebra articulated in situ within the pit of burial 110 (see Figure 69 below). A preliminary interpretation of this wound proposed that it was the result of a coup de grace or a deliberate attempt to efficiently 'finish off' the individual or put the individual out of their misery perhaps.

Figure 69: Context 4247 - Mid-excavation photograph of remains articulated *in situ*, demonstrating deep sharp force cut to cervical region (white arrow).

During laboratory analysis, further traumata were observed to the neck region following refitting of additional fragments of all cervical vertebrae. This reconstructive process also permitted clarification of the injury initially observed during excavation and re-assessment of the social significance of this wound.

Together, these traumata represent a minimum of four peri-mortem heavy sharp force cuts directed at the right side of the neck of the individual, at least one heavy cut to the left side of the neck and a single probable, very thin incision in the throat region.

The first of the cuts to the right side (cut #3) is focussed mainly on the third cervical vertebra (C3), the fragments of which preserve a shallowly oblique linear fracture outline bisecting the right apophysis along with the majority of the neural arch, proceeding from the superior right inferiorly towards the left side (Figure 70 and Figure 71A below). The inferior aspect of the left lamina of the neural arch has likely broken with a slight cortical spall representing a breakaway spur, just medial of the inferior left apophyseal facet.

The C3 vertebra also exhibits a small, very thin, linear lesion (Cut #9?) (3.5 mm and < 0.5mm thin) to the right anterior surface of the vertebral body, just superior to the main oblique fracture margin (of cut #3) that transects the body. This much smaller incision is angled/aligned in a diametrically opposite direction (i.e. it proceeds superiorly from right to left) and potentially represents a peri-mortem slash or stab to the throat of the individual which despite its 'glancing' nature on the bone, if interpretation is correct, would undoubtedly have seriously impacted the soft tissues of the throat.

Figure 70: Context 4247 - Posterior view of C3 vertebra, showing oblique line of cut #3 (white arrow) bisecting vertebral body. See Figure 69 also.

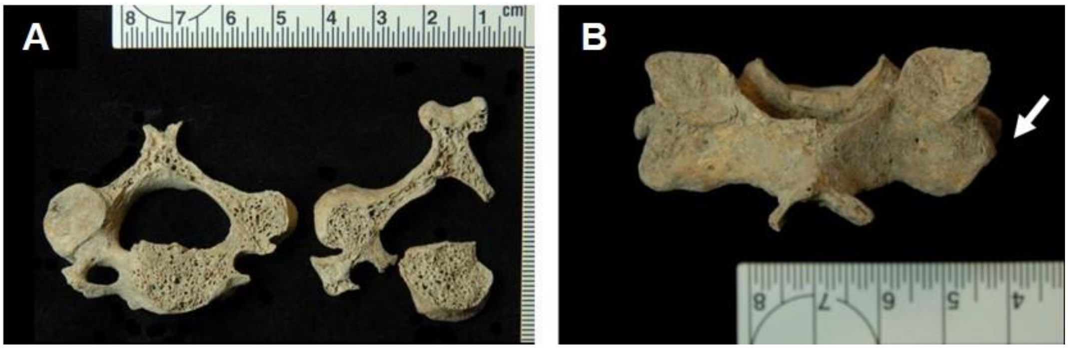

Figure 71: Context 4247 - A) Corresponding fracture surfaces of C3 vertebra, bisected by cut #3 (basal view of superior vertebral fragment on left); B) Posterior view of C4 vertebra, demonstrating start of cut #4 (white arrow) and transection of posterior lateral tip of inferior right apophyseal facet.

The second heavy sharp force cut to the neck (cut #4) represents a heavy blow affecting the fourth to seventh cervical vertebrae (C4-C7). It is more steeply oblique than the first cut described, with the fracture outline commencing at the level of the right apophysis of C4 (Figure 71B). The posterior lateral aspect of the inferior right apophyseal facet has been transected and is missing, with the resulting fracture outline very straight with a flat fracture surface. The line of cut #4 descends steeply towards the left side and has resulted in the almost complete transection of the right apophysis of the C5 vertebra, along with the inferior half of its right neural arch lamina and spinous process. Of note is a linear incision, continuous with the fracture surface, of the posterior surface of the C5 body within the inferior aspect of the extant right pedicle: this suggests only a partial transection of the right side of the neck or, alternatively, an associated end fracture. It is also possible this linear incision may represent an additional cut, made in an almost identical direction/alignment. A fitted broken fragment of the medial left neural arch lamina of C5 also exhibits an irregular fracture outline with spalled fracture surface indicating probable peri-mortem blunt force trauma and likely representing indirect trauma resulting from this deeply penetrating heavy cut.

The fracture line of cut #4 continues inferiorly at a steepening oblique angle downwards, with a possible very slight ‘shave’ defect to the superior margin of the (superior) right apophyseal facet of C6, transection of the superior margin of its right uncinate process and resulting in the bisection of the C6 body. This last exhibits a reasonably straight fracture outline, with a fairly flat, stained fracture surface, although this may alternatively be a result of a combination of the heavy sharp force and its associated end fracture, representing the end of this deep oblique cut through the right side of the neck. The C7 vertebra is almost complete and has not been impacted significantly by this cut, save for a small V-shaped incision into the left lateral aspect of the superior neural arch lamina

(Figure 72). It is also possible this incision or 'nick' may alternatively represent an entirely separate additional cut. However, an even smaller similar lesion is just discernible on the superior posterior intervertebral margin of the vertebral body and is well aligned with the incision to the left lamina and together these orientate well with the line of cut #4.

Figure 72: Context 4247 - C7 vertebra, posterior view, showing v-shaped incision to superior left lamina attributed to the inferior end of peri-mortem sharp force cut #4 (left arrow) and well-defined fracture surface to superior right apophyseal facet associated with cut #7.

The C5 vertebra also exhibits evidence of a horizontal linear fracture running across the inferior right side of the vertebra, with the inferior apophyseal facet surface transected, indicating an additional peri-mortem cut (#5) on the posterior right side of the neck.

A probable fourth cervical sharp force cut (#6), this time to the left side, is suggested by an almost horizontal transverse linear fracture outline across the superior aspect of the left apophysis and uncinate process of the C6 vertebra, resulting in a flat, stained fracture surface. If correctly interpreted, this wound likely occurred later in the sequence of injuries to the neck, as the (inferior) left apophysis of C5 is unaffected, whereas if it had been in anatomical alignment, one would expect it to have been impacted to at least some extent also.

A fifth peri-mortem sharp force cut (#7) is evident to the right side of the neck in the C6 vertebra. The majority of the inferior aspect of the inferior right apophyseal facet has been transected and is missing, with the extant fracture surface very flat and exhibiting some 'polished' cortical bone. In addition, there is a linear incision on the posterior surface of the extant facet which is contiguous with the fracture surface. Associated with this cut is corresponding fracturing and bone loss to the superior lateral aspect of the superior right apophyseal facet of the C7 vertebra (Figure 72). Cut #7 is therefore interpreted as a moderate cut to the lower right neck. Furthermore, the lateral superior aspect of the right neural arch lamina of C6 exhibits a very small incision (c. 1mm in length) with an associated ‘shave’ defect/spall along the superior ridge of the lamina. This small incision and associated defect appear positioned laterally on the right to be associated with the main oblique fracture line of cut #4 and consequently indicate a separate additional peri-mortem injury (cut #8), unrelated to any of the cuts already outlined.

5.3.3.1 Additional cervical observations

The main oblique fracture outline (cut #3) that transects the body and right apophysis of C3 exhibits a slight alteration in angle between the pedicle and the right apophysis. This change in angle represents a possible additional (i.e. third) sharp force cut to this vertebra. If so, this would suggest one blow to the right side of C3 and another more oblique blow (cut #10?), most likely directed from the front, as well as the slash to the throat region suggested by the thin incision.

As described above, the C5 vertebra exhibits significant fracturing with loss, including a missing section within the middle of its right neural arch lamina. The superior fracture margin/surface of this fracture is slightly differently aligned to both of the cuts already mentioned (#4 and #5), with its anterior lateral aspect exhibiting a slightly more steeply oblique orientation than the main oblique cut (#4) which affects C4 to C7. Consequently, a third peri-mortem sharp force cut to the posterior right aspect of C5 is suggested (cut #11?), potentially more indicative of a thrust or stab wound.

There is a small, linear area of fracturing and loss to the anterior lateral aspect of the left apophysis of the C7 vertebra, with an irregular but stained fracture surface (see Figure 72). It is possible this lesion represents a further peri-mortem lesion on the left side of the neck, resulting from either sharp (cut #12?), blunt or penetrating force or a combination of one or more of these but a definite assessment was not possible.

In all, a total of a minimum of six definite and a maximum of four additional possible sharp force cuts to the neck region are evidenced. These include six to the right side (five definite, one possible), two cuts to the left side (one definite and one possible) and two further cuts to the anterior (throat) region (one probable and one possible).

N.B. The numbers attributed to the cuts described above do not indicate the sequence of their timing which remains uncertain. However, there were some indications of overall sequencing of the individual’s injuries – see case study discussion (5.3.6) below.

5.3.4 Context 4247: Postcranial trauma

5.3.4.1 Right scapula

The right scapula exhibits a very clear example of a clean, oblique sharp force cut (#13) which has completely transected the anterior aspect of the lateral tip of the acromion process, with the corresponding acromial tip recovered and present. The fracture surface is very flat, measuring 21.3 mm anterio-posteriorally, with its posterior cortical component presenting a 'polished' appearance. The fracture outline is slightly ragged towards the anterior (likely due to the thinner cortical component). This wound represents a definite peri-mortem wound from a heavy blade to the posterior right shoulder. The recovery of the transected tip of the bone clearly indicates enough soft tissue remained in place to retain the separated fragment in close association with its anatomical position, despite the deeply penetrating nature of the injury. Evidence of another, small, glancing cut (#14) was also observed, largely limited to cortical involvement and measured 8.2 mm medio-laterally and 6.4 mm anterio-posteriorally (Figure 73 below).

Figure 73: Context 4247 - Right scapula, showing detail of fully penetrating peri-mortem sharp force cut to acromion, representing cut #13 (upper white arrow) and retained lateral acromial tip (top right). Note evidence of another, lighter/glancing peri-mortem cut (cut #14) to the posterior aspect of superior surface (lower white arrow).

The right scapular blade also exhibits a complete transverse fracture across inferior lateral border with the inferior angle missing. This fracture exhibits an irregular surface as well as an irregular outline. The fracture angle was bevelled somewhat anteriorly (i.e. from superior posterior/dorsal to inferior anterior/ventral) and the fracture surface stained, suggesting the possibility of peri-mortem blunt force trauma, potentially resulting from a blow to the back of the right shoulder, although there is insufficient evidence (e.g. radiating fractures/ smooth cortical fracture surfaces/ hinged or flaked fragments) in this instance to confirm this.

5.3.4.2 Right clavicle

The right clavicle also exhibits clear evidence of a peri-mortem sharp force cut (Figure 74). The inferior aspect of the lateral end of the bone exhibits a transverse linear fracture, exposing the trabeculae across a very flat fracture surface, somewhat deeper than a ‘shave’ defect. The corresponding inferior cortical surface fragment is also present and exhibits plastic deformation.

Figure 74: Context 4247 - Right clavicle, showing detail of peri-mortem sharp force cut across inferior aspect of lateral end and retained cortical surface fragment.

5.3.4.3 *Right humerus*

There is also an area of slight 'polish' (c. 8.4mm by 2.5mm maximum) on the inferior medial aspect of the right humeral head. The region also exhibits a very shallow depression which can be felt and is visible in profile (< 0.5mm deep). These changes also suggest probable very slight (i.e. glancing) peri-mortem sharp force trauma to the right shoulder region, slightly impacting the right humerus. It is not certain whether the cuts to the right clavicle and the right humerus represent one or more separate injuries to the right shoulder in addition to the cut observed in the right acromion.

There is the possibility that the three bones (or at least the scapula and the humerus) could have been impacted by the same blow, depending on the position of the upper limb/body at the time of the injury occurring: it is possible this may have been the case if the right upper limb of the victim had been raised at the time the individual was struck.

In addition, the proximal right humerus exhibits a slightly oblique, one-sided, linear- edged depression (with a minimum length of 8.9mm, a maximum width of 4.7mm and a minimum width of 2.6mm) in the centre of the lesser tubercle which tapers anteriorly. This lesion is interpreted as possibly representing either peri-mortem blunt force and/or sharp force trauma to the right shoulder. The midshaft exhibits a recent post-mortem (i.e. dry) transverse fracture, with the cortical fracture margin surfaces granular in texture. The characteristics of this recent breakage serve to highlight the potential peri-mortem nature of stained and smooth/irregularly textured fractures observed in other fragments from the two burial deposits.

The distal end of the humerus exhibits a complete fracture, with the distal metaphysis including the trochlea and medial epicondyle present as a separate fragment. The distal fragment is also fractured across its anterior articular surface, with the associated loss of the capitulum (not present). The main fracture of the metaphysis presents an irregular fracture outline and an irregular fracture surface. The region is burnt and partially blackened and there is also some erosion. However, the fracturing and loss of the capitulum are clearly indicative of old a dry fracture at least and are potentially peri-mortem in timing. These fractures suggest possible blunt force trauma to the region of the right elbow, most likely focussed on the lateral aspect. It is worth noting that the burning is limited to the anterior aspect of the metaphysis, although there is some erosion on the posterior aspect of the proximal metaphyseal fracture surface. Differential diagnosis acknowledges the possibility that thermal alteration may be responsible for the fracturing of the metaphysis at least, (although this seems unlikely to explain the fracture and loss of the capitulum); conversely, thermal alteration may also have degraded/disguised the fracture area of any changes related to peri-mortem trauma.

5.3.4.4 Left scapula

The left scapula (represented by context 4269) is almost complete and in a good state of preservation, with evidence for multiple fractures most likely occurring within a peri-mortem timeframe. There is probable peri-mortem blunt force trauma in the form of a complete transverse fracture across the glenoid cavity (see Figure 75C below) and the superior border. The fracture surface across the extant superior portion of the glenoid is relatively flat, although no 'polished' cortical surface is discernible, and is stained (i.e. not related to recent post-mortem breakage).

The inferior aspect of the posterior surface of the lateral tip of the left scapular acromion process exhibits a shallow, somewhat linear impression/depression, with depressed/ hinged/retained fragments of cortical surface *in situ* (Figure 75B). Associated with this area of depression are some very small, incomplete radiating fractures, as well as some breakage proceeding around the posterior edge of the left acromion. There is some post-mortem breakage to the superior medial border of the left scapular blade which potentially occurred during excavation and recovery, although it is not absolutely certain this breakage is recent.

Overall these changes suggest probable peri-mortem blunt force trauma to the back of the left shoulder. A third area of probable peri-mortem blunt force trauma, this time to the medial side of the bone was also evident (Figure 75F). The midpoint of the medial border of left scapular blade exhibits a well-defined, three-sided penetrating lesion/fracture with probable sub-oval or sub-rectangular form at an angle of 45° to the transverse plane. The fracture surfaces were irregular with a slight anterior bevel (i.e. from inferior posterior/dorsal to superior anterior/ventral). The well- delineated margins of this fracture, together with the stained fracture surfaces and the evidence of bevelling/spalling strongly suggest this lesion represents a peri-mortem blunt force impact indicative of a heavy blow penetrating the central left region of the upper back.

Sharp force trauma is likely also present in the left scapula, evidenced by an oblique linear fracture to the inferior portion of the left scapular blade, with the inferior angle transected and missing. A very straight, linear fracture outline remains, with a consistent, flat fracture surface and a single small, incomplete radiating fracture proceeding across the anterior surface away from the mid-point of the fracture line (Figure 75E). The majority of this fracture surface is stained and there is some evidence of burning/blackening to the extant inferior left scapula. It is probable this linear fracture represents an oblique peri-mortem blade strike (cut #15) across the inferior aspect of the back of the left shoulder.

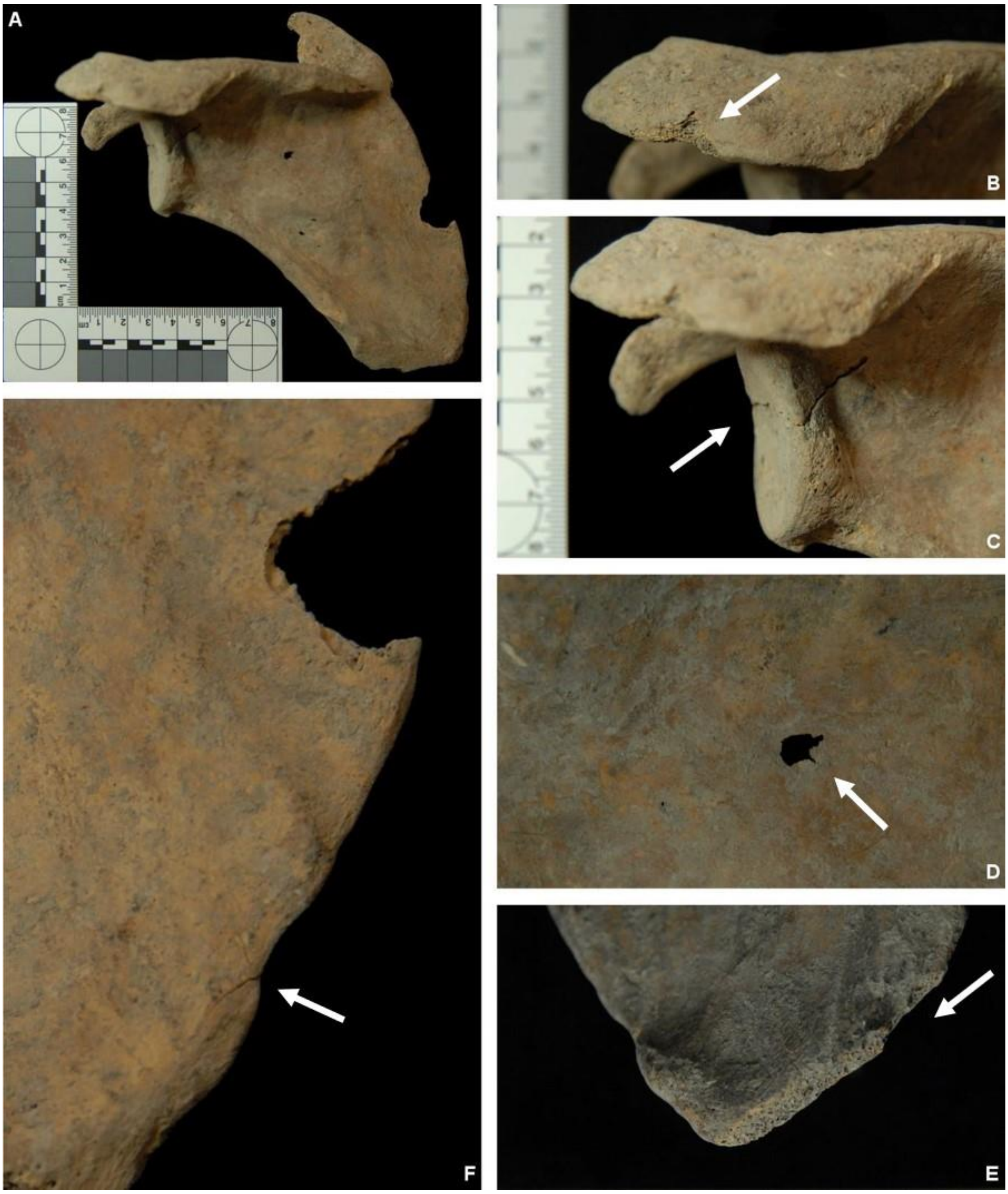

Figure 75: Context 4247, A) Left scapula showing: B) Possible blunt force trauma of posterior aspect of acromion; C) Possible peri-mortem blunt force fracture of glenoid cavity; D) Possible peri-mortem penetrating trauma, with linear notch; E) Probable peri-mortem sharp force trauma across inferior scapular blade represented by oblique linear fracture (white arrow) with stained fracture surface and inferior angle transected and missing; F) Three-sided fracture suggestive of shaped (rectilinear?) blunt force traumatic lesion of the medial border, with irregular, stained fracture surface indicative of peri-mortem timing. Note additional incomplete fractures radiating away from the medial border inferior to the missing rectilinear section (white arrow).

Finally, there is a small, almost semi-circular penetrating lesion to the superior scapular blade, with a possible very small, linear notch inferiorly (Figure 75D). The lesion displayed maximum dimensions of 5.0 mm transversely and 4.2 mm in the sagittal plane, with 1.8 mm of the latter constituting the linear lesion within the inferior margin. The margins of the lesion appear bevelled posteriorly, with an irregular fracture surface anteriorly suggesting the possibility of a peri-mortem projectile (PFT) or a sharp force stab wound to the posterior left shoulder evidently from behind. Alternatively, however, it may simply represent the result of either a congenital or a developmental defect in the scapular blade (Mitchell, pers. comm.).

5.3.4.5 Left humerus

The lateral posterior aspect of the surgical neck of the left humerus exhibits a thumb- sized shallow impression/depression of the cortical surface, with only very faint fracture lines visible. Slightly superior to this is a more definite area of breakage with the posterior aspect of the greater tubercle crushed/depressed to a more significant degree within a smaller (little fingertip-sized) area and depressed/hinged fragments retained *in situ*. These changes potentially represent a minimum of one peri-mortem blunt force impact to the left shoulder. Alternatively, they may represent pseudotrauma resulting from old post-mortem breakage due to post-depositional crushing or compaction of the remains within the grave pit.

There is also a complete, oblique fracture to the diaphysis of the left humerus, just below the midshaft which exhibits a helical/spiral fracture outline with a fracture surface which is somewhat irregular but with cortical fracture surfaces which are relatively smooth in texture. Proximal to the broken end of the humerus are several incomplete, radiating fractures, aligned both longitudinally and transversely. The region is also burnt and partially blackened, with at least some breakage likely attributable to thermal alteration. However, the possibility remains that the fractured shaft of the left humerus is the result of peri-mortem blunt force trauma to the left arm.

5.3.4.6 Thoracic vertebrae

There is an incomplete fracture running across the base of the superior right apophyseal facet of the third thoracic vertebra, representing probable peri-mortem blunt force trauma to the mid-back region. This injury is potentially associated with very similar fracturing/loss of the right transverse processes of the second through fourth thoracic vertebrae.

5.3.5 Context 4247: Antemortem changes

In addition to the peri-mortem traumata already described, context 4247 also exhibited evidence of probable antemortem trauma and other antemortem changes.

Within the cranium, the superior endocranial surface of the left petrous portion exhibited a concentration of macroporosity, just anterior and lateral of the arcuate eminence, in the region of the petrosquamous fissure. This focal lesion appeared erosive in nature, with sharp-edged perforations of a consistent size (Figure 76). Such focal macroporosity has been observed on several other temporal bones amongst the crusader remains by the author, all with similar positioning and features. It is suggested that these lesions represent some sort of antemortem pathology, possibly of an age-related nature (all those observed belong to remains considered mature adults). Potentially, these lesions represent the result of a cholesteatoma, but x-ray visualisation is needed for confirmation (Schutkowski, pers. comm.).

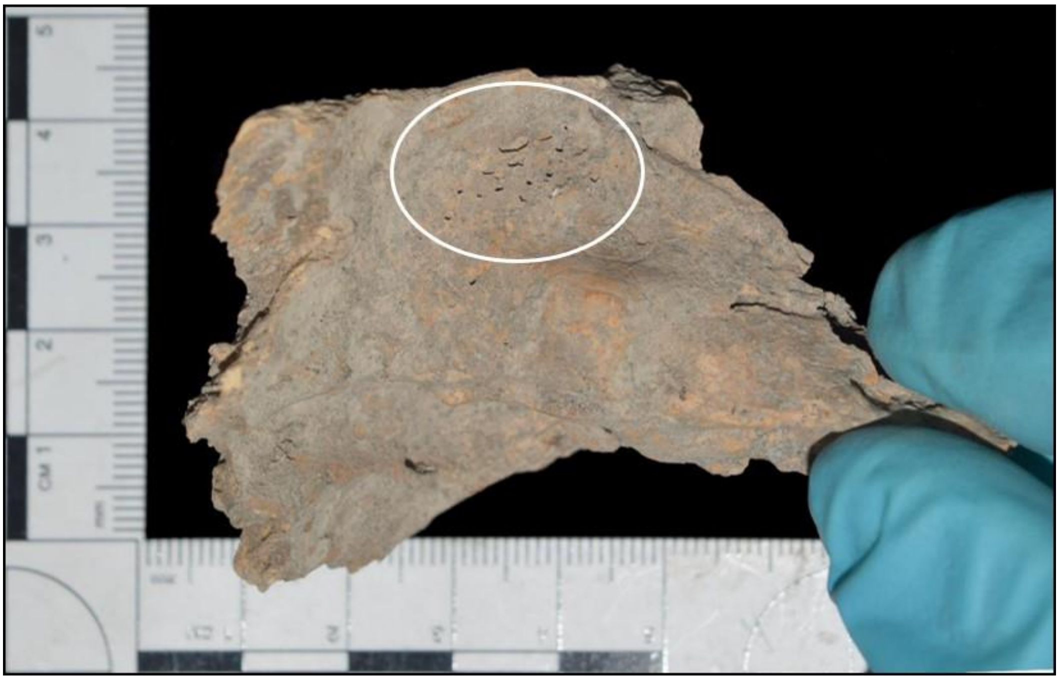

Figure 76: Context 4247 – Left Temporal, view of superior endocranial surface of left petrous portion, showing concentration of sharp-edged macroporosity/erosive lesion, representing possible antemortem pathology.

The T3 vertebra is well-fused to the T4 vertebra, with complete ankylosis across almost the entirety of the intervertebral body margins (excepting a very small retention of the intervertebral disc space on the anterior left aspect. The left costal facets are still well-delineated and almost separate, whilst the right costal facets appear almost fully amalgamated except for a remnant shallow, linear channel centrally. The laminae of the spinous processes are very well ankylosed, particularly on the left side where they almost appear to represent a single tall/broad spinous process, the right aspect still retains a clear delineation between the two processes, with the tips joined by what appears to be at least partial ossification of the supraspinous ligament. These changes suggest antemortem changes separate to the peri-mortem timeframe. Healed trauma is suggested as a possibility, yet perhaps congenital fusion is a more likely explanation in this case, given the smoothness of the bony bridging between the neural arches and the slight retention of the line between them.

Additionally, the T6 vertebra exhibits marked morphological irregularity of the majority of the dorsal surface of the neural arch with new and remodelled compact bone evident. Both sides of the neural arch laminae also exhibit a discontinuous line. Together, these changes are indicative of a well-healed antemortem fracture of the spinous process, suggesting the individual had potentially suffered a blunt force blow to the middle of the back. Alternatively, it is also possible these changes may be attributable to a stress fracture resulting from repetitive loading characterising the individual's lifestyle or possibly their occupation. In either case, the injury had healed well by the time of death, likely having occurred at least months previously. There is also some slight ossification of the supraspinous ligament evident to the tip of the spinous process of the T6 vertebra, potentially related to the healed trauma in the neural arch. Alternatively, the modification of the spinous process may suggest an association with the changes observed in the T3 and T4 vertebrae.

5.3.6 Context 4247: Discussion

Despite a lack of overlap or direct association between these modifications, their location and severity provide possible indications of the relative sequencing of at least some of the injuries they represent.

The nature and number of the traumata of the neck is especially striking. In particular, the deep, almost horizontal cut across the body of the third cervical vertebra (cut #3) and the steep oblique cut that penetrated deeply into the neck affecting the fourth through seventh cervical vertebrae (cut #4), are considered catastrophic wounds and almost certainly fatal, assuming the individual was not already dead at the time they were sustained. Following such wounds, it is highly improbable the individual would have been capable of continuing to fight effectively or otherwise defend himself.

The ‘scoop’ lesion to the posterior left side of the cranium (cut #1) in all likelihood represents a glancing blow from a heavy, sharp-edged weapon such as a sword or possibly an axe, although the relative lack of significant radiating fractures directly associated would argue against the latter. Such a glancing blow suggests either a poorly directed swing by the assailant or perhaps more likely, the individual under attack attempted to move their head out of the way or otherwise defend against the blow. The limited penetration and lack of significant radiating fractures arising from this lesion also suggests the possibility the victim was wearing a helmet of some sort or some other form of head protection. The deep cut to the right aspect of the occipital has penetrated completely through almost the thickest part of the cranial vault and thus exposing the endocranium and brain tissue, would in all likelihood have been fatal. The heavy cut which resulted in the complete transection of the lateral acromial tip of the right scapula (cut #13), although a serious injury which would have required immediate treatment, would not necessarily have resulted in death, unless the brachial artery had been severed or lacerated to some degree at least. The latter situation seems unlikely given the anatomical position of the acromion process at the posterior of the scapula and the positioning of the brachial artery towards the anterior and inferior of the region of the acromion.

It is possible both the slicing cut across the inferior surface of the right clavicle and the small superficial slice across the superior articular surface of the right humeral head occurred as a result of the same strike which transected the acromial tip. If so, one can infer that the right upper limb was possibly raised, perhaps in defence or alarm. The angle of the transection through the acromion indicates the individual was struck from behind and possibly from the right, although this is dependent on his body position at the time he was struck. The additional subtle evidence of at least one other cut to the posterior right scapula, represented by the small but well-defined area of slight cortical loss to the posterior aspect of the superior surface of the acromial process (Figure 73) suggests that this region was targeted.

Excepting a potential frenzied attack in the heat of battle, it would not make sense for an assailant, already having succeeded in dealing such a serious injury to the neck and throat of their opponent, to then strike the back/top of the shoulder nor to deal repeated blows to the head. Overkill and atrocities are certainly phenomena recognised in modern warfare contexts and the former has even been interpreted in archaeological contexts (Geber, 2015: Skeleton 42 from Owenbristy, Ireland; Novak, 2007: 100-101, Towton 25) and thus constitutes a possible interpretation. However, it seems most likely that the cuts across the right side of the neck represent not a random frenzy, but rather a precisely targeted and ruthlessly effective final assault finishing off the individual who had most probably been incapacitated already by the heavy cut to the right shoulder at least and possibly also the glancing blow across the left side of the head as well as the other more widely distributed evidence of probable trauma.

Taken together, the distribution of the trauma (see Figure 63), particularly the multiplicity of cuts to the right shoulder, posterior right side of the head and neck suggest deliberate and persistent targeting of this area of the body, in all likelihood by one or more right-handed assailants. The positioning of these injuries and the 'glancing' cut across the posterior left side of the cranium are also consistent with the assailant inflicting the blows from an elevated position relative to the victim, as would be the case if the assailant were mounted on horseback and the victim on foot.

The majority of the cuts described above suggest a heavy, very sharp bladed weapon with, in all likelihood, an extended blade length or a long handle. A sword or axe have both been shown to produce such injuries in bone (de Gruchy and Rogers, 2002; Lewis, 2008b; Lynn and Fairgrieve, 2009; Nagaoka et al., 2010; Nicklisch et al., 2017; Sauer et al., 1988; Williamson et al., 2003), although one might expect greater evidence of blunt force with the heavier load of an axe.

The presence of numerous fragments of ossified thyroid cartilage suggest the individual may have been a mature adult, although the ossification of laryngeal cartilage is not considered to be a reliable indicator of age-at-death (Turk and Hogg, 1993).

5.4 Case Study 2: Context 4147

5.4.1 Summary

Context 4147 represents the most complete individual from burial 101, the smaller grouping of human remains identified outside the rectilinear grave cut of burial 110, approximately half a metre to the northeast. The skeletal remains (Figure 77) consisted of a largely well-articulated cranium, mandible, neck, torso and the almost complete right arm and hand, representing an adult of male sex (again confirmed by the DNA analysis carried out by Haber et al. (2019)). A right femur, a left *Os coxae* and a left patella were also loosely associated with the upper body and vertebral column, but it has not yet been possible to confirm if these belong to the same individual.

The extant cranium and mandible exhibited evidence of multiple blunt force traumata and wounds resulting from sharp force trauma were present on postcranial elements, with multiple injuries of the neck and spine including penetrating trauma. In total these blade injuries constituted a minimum of three sharp force cuts, including at least two cervical injuries and a single heavy cut across the middle of the back (Figure 78). Possible evidence for an additional sharp force cut across the face was also observed.

Figure 78 shows the distribution of all definite and probable perimortem trauma across the extant skeleton known as context 4247.

Figure 77: Burial 101 - Mid-excavation photograph showing the skeletal remains representing context 4147 in situ. Note the deviated aspect of the mid-thoracic spine (white arrow), with the head and neck almost 90°, relative to the lower spine.

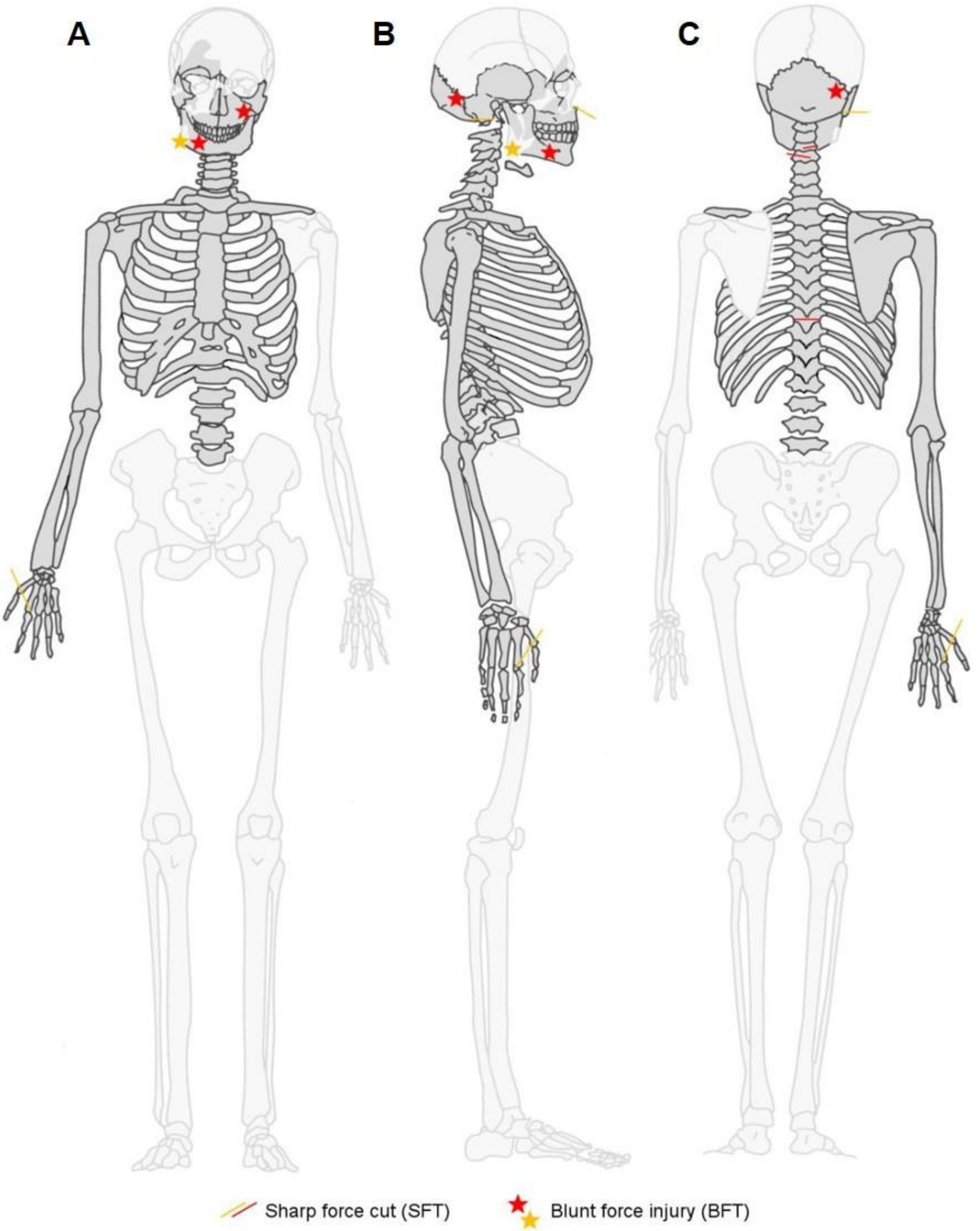

Figure 78: Context 4147 - Distribution of all peri-mortem traumata (high (red) and moderate (yellow) confidence) across extant skeleton: A) Anterior view; B) Lateral right view; C) Posterior view.

5.4.2 Context 4147: Cranial trauma

The cranium and mandible of context 4147 exhibited evidence of peri-mortem blunt force trauma to multiple regions of the head, suggesting at least three blunt force impacts: one to the posterior right side of the head, one to the left side of the face and another blow to the right lower jaw. The first of these is attested by a fracture exhibiting sharp margins with slight internal bevelling, helical in appearance, observed on the lateral right squamous portion of the occipital. The occipital had also suffered an associated probable radiating fracture, proceeding medially across the external occipital protuberance towards the left lambdoid suture, although some overlying, recent post-mortem breakage was also evident. A further radiating fracture, possibly relating to these changes, proceeds medially from the mid-section of the right lambdoid suture towards the centre of the occipital. These fractures represent a probable peri-mortem blunt force impact to the back of the head focussed on the posterior right side.

The anterior aspect of the cranium exhibits an incomplete, radiating fracture of the left alveolar process, possibly associated with a linear fracture across the anterior left maxilla that proceeds from the left margin of the nasal aperture down towards the posterior left alveolar process. This latter fracture is stained and potentially peri-mortem in timing, although some recent overlying post-mortem breakage was also observed. The incomplete fracture of the alveolar process, together with the potentially peri-mortem fracture across the left maxilla, suggest probable peri-mortem blunt force impact to the left side of the face. Differential diagnoses would include a possible peri-mortem projectile/penetrating injury (PFT) to the left side of the face – potentially evidenced by a small, missing section of bone in this region; as well as a combination of peri-mortem blunt force impact (evidenced by the incomplete fracture) and old post-mortem breakage (represented by the fracture across the left maxilla).

The central aspect of the right mandibular body exhibits an internally bevelled fracture surface which is stained, suggesting a probable peri-mortem blunt force to the right side of the jaw. In addition, external spalling was also noted to the gonial angle of the right mandibular ramus, again with stained fracture surfaces. A third possible area of peri-mortem fracturing of the right corpus of the mandible was evident at the coronoid process which also exhibited some burning/charring, along with some slight recent post-mortem breakage. These latter changes support the indication of peri-mortem blunt force trauma to the right side of the mandible, but it was not possible to say whether they represented separate traumatic events to that causing the main fracture to the right mandibular body.

5.4.2.1 Additional cranial observations

Possible sharp force trauma was present on the anterior maxilla, with a flat-looking, possible transverse cut(?) surface across the anterior nasal spine. The fracture surface appeared stained, although it was difficult to exclude the possibility that the bone had been remodelled. The morphology suggests a possible peri-mortem blade strike across the nose/upper lip region, with the inferred transection and loss of the anterior nasal spine. Differential diagnosis includes antemortem remodelling, representing a healed injury.

5.4.3 Context 4147: Cervical trauma

The C3 vertebra exhibited evidence of a sharp force cut across the right side of the neural arch with the transection and loss of its inferior aspect and likely the inferior right apophyseal facet as well (Figure 79A). The fracture surface is very flat and consistent and is stained, indicating this cut is peri-mortem. Its positioning suggests a heavy blade strike across the posterior right side of the upper neck.

The C4 vertebra also presents convincing evidence of a heavy sharp force blow to the back of the neck (Figure 79B). The superior aspect of the right neural arch lamina exhibits a very flat, consistent cut surface with slight polish. This is most obvious towards its lateral extent where it is continuous with a transverse incision into the posterior medial aspect of the superior left apophyseal facet. This incision narrows to a point laterally, with at least two incomplete end fractures radiating away laterally from the limit of the incision. These fractures may have been the result either of the force of the cut itself or, alternatively, they represent secondary blunt force trauma as the blade was removed.

It is difficult to be certain whether the sharp force lesions visible on the inferior C3 and superior C4 neural arches are associated with either a single blow or multiple strikes. However, the oblique angle of the cut surface of C3 is possibly too steeply orientated to have resulted in the cut and incision to the superior left side of the C4 vertebra, although this is dependent on body positioning at the time of this attack. In addition, the C3 cut was focussed on the right side, whilst the cut to C4 was more evenly balanced across the posterior, perhaps with a slight focus towards the left. Consequently, these injuries have been interpreted as representing two separate cuts, although an alternative interpretation includes a single heavy cut across the back of the neck, penetrating both neural arches coming to a stop within the left apophysis of C4. In the case of the latter, the wound would not have been complete decapitation.

Figure 79: Context 4147 - A) Inferior view of C3 vertebra, showing flat, stained fracture surface indicative of a heavy sharp force cut across the posterior right side of the upper neck; B) Sharp force cut across the superior lamina of C4 vertebra with 'polish' evident (white arrows) and limit of cut illustrated by incision within posterior medial aspect of superior left apophyseal facet and associated incomplete end fractures radiating away from site.

5.4.3.1 Additional cervical observations

There is also some modification of the superior lateral aspect of the superior right apophyseal facet of the C5 vertebra. It is possible this alteration may represent a 'shave' defect (i.e. sharp force trauma) and potentially relates to the sharp force cuts to the C3 and C4. However, there is clearly some more recent-looking breakage of the lateral aspect of the facet, indicative of either post-mortem breakage or possible peri-mortem blunt force trauma with subsequent post-mortem breakage.

5.4.4 Context 4147: Postcranial trauma

5.4.4.1 Thoracic vertebrae

The ninth thoracic vertebra (T9) exhibits strong evidence of a transverse sharp force cut, completely penetrating the neural arch which was present and in relative articulation in situ but with little of the vertebral body in evidence. Although the fracture surface and outline are both slightly irregular, the overall appearance was quite linear and the fracture surface stained, indicating the peri-mortem nature of the injury. Recalling the rather unnatural flexed nature of the thorax in situ (see Figure 77), it is possible the injury to the T9 vertebra facilitated this unusual angulation of the spinal column observed during excavation. Certainly, the positioning of the remains lends support to the interpretation that some sort of discontinuity had occurred in the mid-spine in antiquity and most likely prior to deposition.

5.4.4.2 Context 4147: Additional postcranial observations

The majority of the distal articular head of the right first metacarpal (MC1) was missing, and the broken distal end exhibited a reasonably linear, oblique fracture outline across the distal end, with a quite flat-looking and well-stained fracture surface.

Multiple fragments of the extant right scapula exhibit irregular fracture outlines with irregular, stained fracture surfaces and some bevelling/spalling apparent. There is also a semi-circular impression with associated fracturing/exposure of trabecular bone, at the inferior aspect of the ventral surface of the right scapular blade, with some overlying recent post-mortem breakage also evident. These changes potentially represent one or more possible peri-mortem blunt force impacts to the right shoulder, but taphonomic causes such as post-depositional erosion could not be ruled out at the time of assessment.

5.4.5 Context 4147: Antemortem changes

The extant right first metacarpal (MC1) was very robust, possibly with marked remodelling or even shortening, strongly suggestive of a probable well-healed fracture, most likely due to blunt force trauma (see Figure 107)

Cribra orbitalia was present in the extant right orbit (score = 3.2 – 4.2 – Smaller and large foramina, some possible linking in with trabeculae evident, probably healed to some degree at least).

A single right rib fragment exhibited evidence of marked new bone deposition on the ventral surface of the shaft in close proximity to the angle. The extant deposit appeared compact with some remodelling, although its surface was irregular, with a slightly spiculated texture. The area of the deposit was relatively well-defined and oval in form and overlay the superior limit of the costal groove (see Figure 108).

A second right rib fragment exhibited a small, well-defined deposit of compact new bone on the anterior ribshaft surface of the ribshaft. The deposit was isolated and took the form and approximate size of a rice grain. Differential diagnoses include a well-healed traumatic lesion (possibly a piercing of the rib resulting from non-penetrating trauma) or, alternatively, a neoplastic origin such as a benign osteoma (see Figure 108B).

5.4.6 Context 4147: Discussion

The trauma evidence observed in context 4147 supports the overall interpretation associating the human remains from both burials with a single violent event such as a battle or massacre. The evidence from this individual also echoes that of context 4247, with the confirmed sharp force trauma focussed on the posterior body.

5.4.7 Other key examples

Images of other examples of peri-mortem traumata observed in the Sidon remains are included in APPENDIX A9: Peri-mortem Trauma (Other Examples).

Descriptions of all definite peri-mortem traumata are included in Table 50 and Table 51 in APPENDIX A7: Peri-mortem Trauma (Definite) Descriptions.

Additional images of the remains are included in a separate disc (APPENDIX A15: Animation of 3D reconstruction of cranial fragments of context 4247), with filenames searchable using key descriptors including context number.

5.5 Results: Antemortem Trauma

5.5.1 Summary

The main types of antemortem trauma recorded in the course of palaeopathological studies include healed or healing weapon trauma (e.g. Boylston, 2000; Novak, 2007), healed or healing accidental trauma, dislocations, ligament or other soft tissue trauma with subsequent new bone formation or ossification of muscle (myositis ossificans), subperiosteal haematomas and other healed/healing fractures (Ortner, 2003). The types of antemortem trauma observed in the crusader skeletal material from burials 101 and 110 included healed, indirect fractures; a healed, direct (depressed) fracture; possible haematoma; multiple cases of probable rotator cuff syndrome; osteochondritis dissecans; and inflammatory response represented by new bone deposition and remodelling. In addition, there were also probable cases of the following: myositis ossificans and periosteal infection.

Figure 80 and Figure 81 illustrate the distribution of all antemortem traumata observed in the human remains from burial 101 and 110.

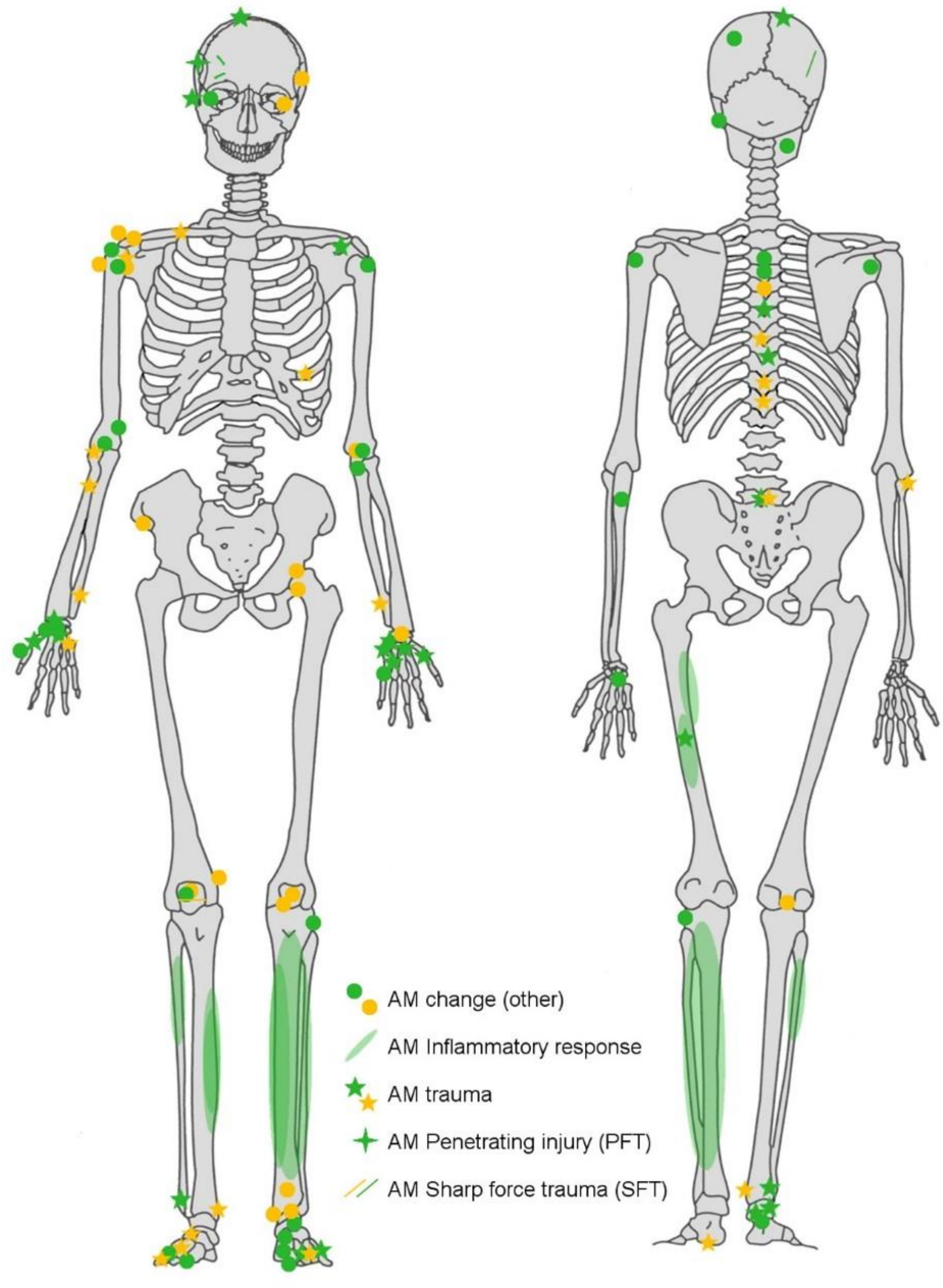

Figure 80: Distribution of all antemortem changes (high (green) and moderate (yellow) confidence) across anterior (left) and posterior (right) aspects of skeleton.

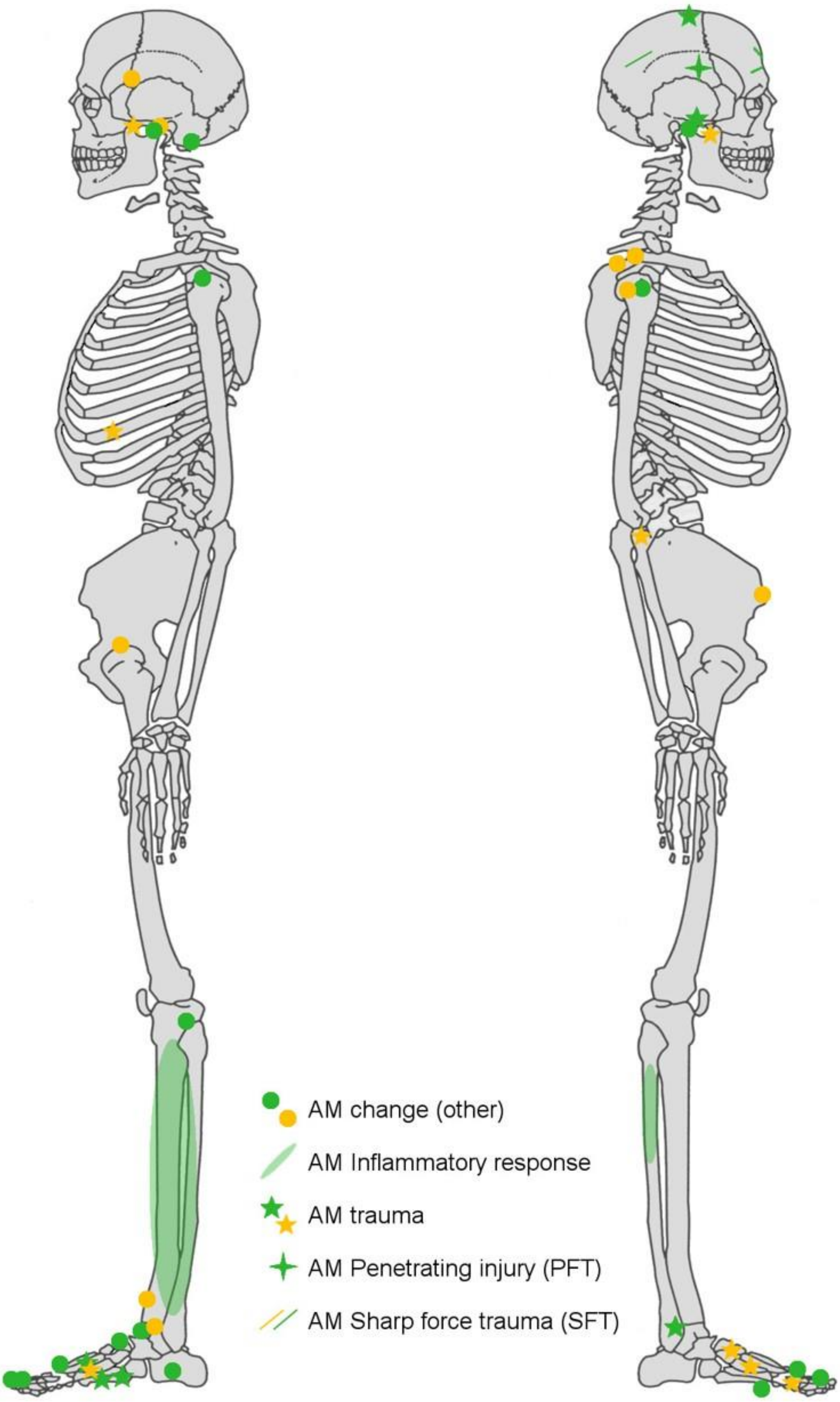

Figure 81: Distribution of all antemortem changes (high (green) and moderate (yellow) confidence) across left (left) and right (right) aspects of skeleton.

Several fragments exhibited evidence of probable healed sharp force weapon trauma. Context 4271 exhibits a linear/rectilinear depression obliquely aligned across the inferior anterior aspect of the right frontal, just superior to the supraorbital ridge. This lesion is indicative of probable well-healed trauma, most likely originally resulting from a sharp force injury or alternatively an edged blunt object. A cranial fragment from the grid layer region (4203_F_L6) exhibited a similar, linear discontinuity to the ectocranial surface of the right frontal, located once again above the supraorbital ridge and just below the right frontal boss. Although this lesion was barely discernible with the naked eye, it was never- the-less tangible across the cortical surface. This remodelled bone also indicates probable well-healed trauma (again either edged blunt force or sharp force trauma), although differential diagnoses include both unusual natural(?) morphology and a healed/healing infective process in this case.

Another cranial fragment from the superficial layer of bones in burial 110 (4180_L1_Top) exhibited a penetrating injury which demonstrated signs of well-established healing (see Section 5.6).

Other antemortem healed trauma included one individual exhibiting spondylolysis of the L5 vertebra; at least one individual with a well-healed fracture of the midshaft of the left fifth metatarsal, with slight lateral angulation; a further individual also with evidence of an antemortem fracture to the lateral aspect of the proximal end of the left fifth metatarsal, but with limited healing; tentative evidence of well-healed fractures to some rib shaft fragments; and at least one good example of an avulsion fracture. This last affected the left wrist, with complete separation of the hook of hamate from the hamate body. A further possible avulsion fracture was noted, consisting of a classic *os acromiale*.

Descriptions of all antemortem traumata are included in APPENDIX A8: Antemortem Changes.

5.6 Case Study 3: Antemortem Healed and Healing Trauma

5.6.1 Summary

As mentioned briefly above, one individual demonstrated evidence of having been involved in at least two separate, earlier violent encounters. This individual was represented by a single, large cranial fragment from the superficial layer of bones in burial 110, uncovered in 2009 and known as (4180_L1_Top). This fragment consisted of the majority of the anterior and superior right parietal, along with a section of the right coronal suture and associated fragments of the right lateral aspect of the frontal. The parietal exhibited a penetrating injury which demonstrated signs of healing, as well as evidence of a very well-healed sharp force cut to the posterior right side of the head (Figure 82A).

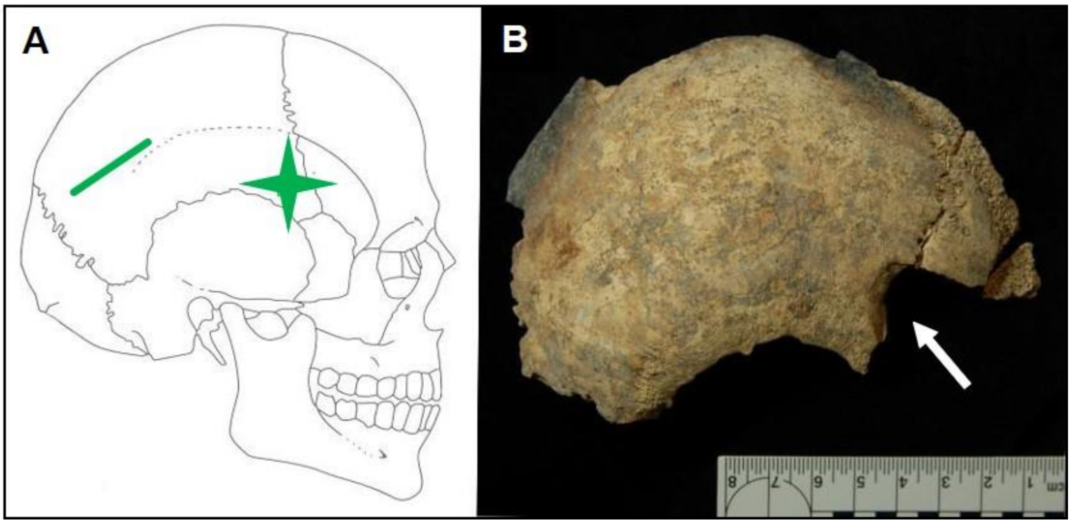

Figure 82: A) Distribution of antemortem trauma in single cranial fragment recovered from the uppermost layer of remains in burial 110; B) Lateral view of the cranial fragment, representing the majority of the right parietal, with the antemortem penetrating injury evident to its anterior lateral aspect (white arrow).

In this case, a large perforation penetrated both tables of the anterior lateral right side of the cranium, just posterior to the right lateral aspect of the coronal suture (Figure 82B). The lesion demonstrated a minimum width of 7.2mm externally, and 2.6mm internally; the minimum length was 18.9mm externally and 12.0mm internally. The extant margins were remodelled, with the posterior margin consisting of a flat surface (Figure 83).

This lesion is clearly indicative of healing antemortem trauma, most likely weapon trauma which must have occurred at least a few weeks, if not months, prior to the death of the individual (cf. Barbian and Sledzik, 2008; Ortner, 2003).The original injury cannot therefore be attributed to the conflict event which led to the deaths of this group of Crusaders and the deposition of burials 101 and 110, (assuming the group died in a single event).

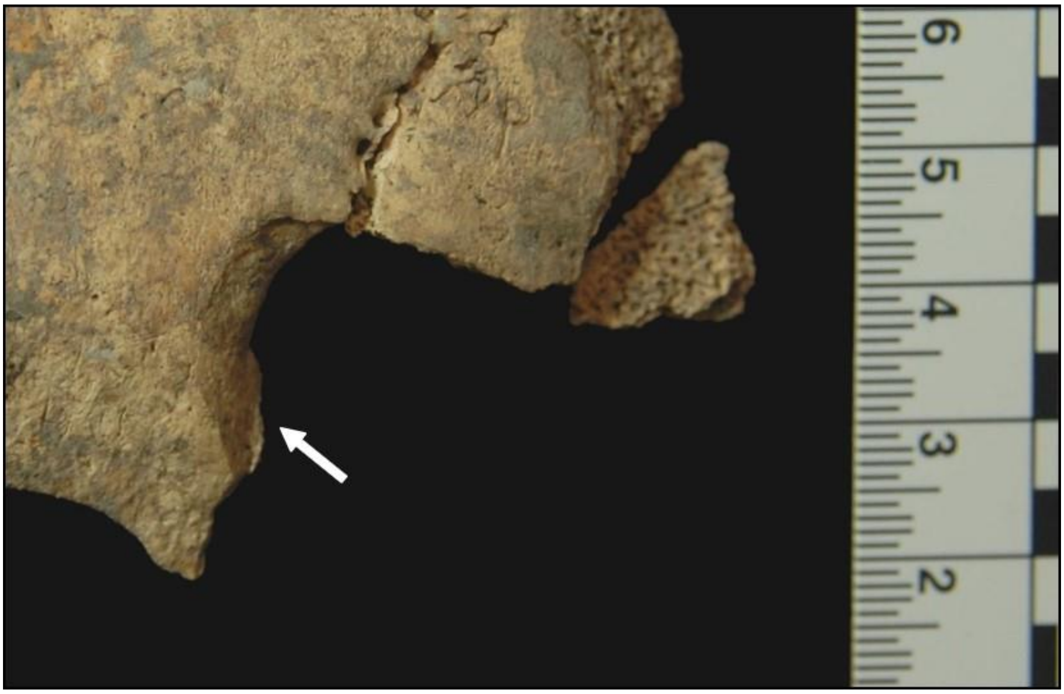

Figure 83: Cranial fragment (from context 4180_Top): Detail of antemortem penetrating lesion, with extant margins exhibiting remodelling and obliteration of the diploë (white arrow), indicative of advanced healing prior to death.

Very subtle evidence of a probable second antemortem injury is also present on this cranial fragment. There is a very slight linear ridge at the posterior lateral aspect of the extant right parietal (see Figure 82A). Associated with this linear ridge is some marked porosity of the ectocranial surface. The position of the ridge and a lack of continuity towards the anterior suggests it has not been formed by the attachment of the temporal muscle (M. temporalis) (i.e. it is not part of the temporal line). The most likely interpretation is that this linear ridge represents a very well-healed fracture, possibly due to a long sharp blade, which occurred a long time (i.e. months, if not years) before the individual’s death. Furthermore, the degree of healing is such that it is highly unlikely the injury occurred at the same time as the open but healing penetrating wound to the right side of the head. These two injuries together suggest the individual was a recidivist, subject to repeated trauma due to consistent involvement in crusader warfare.

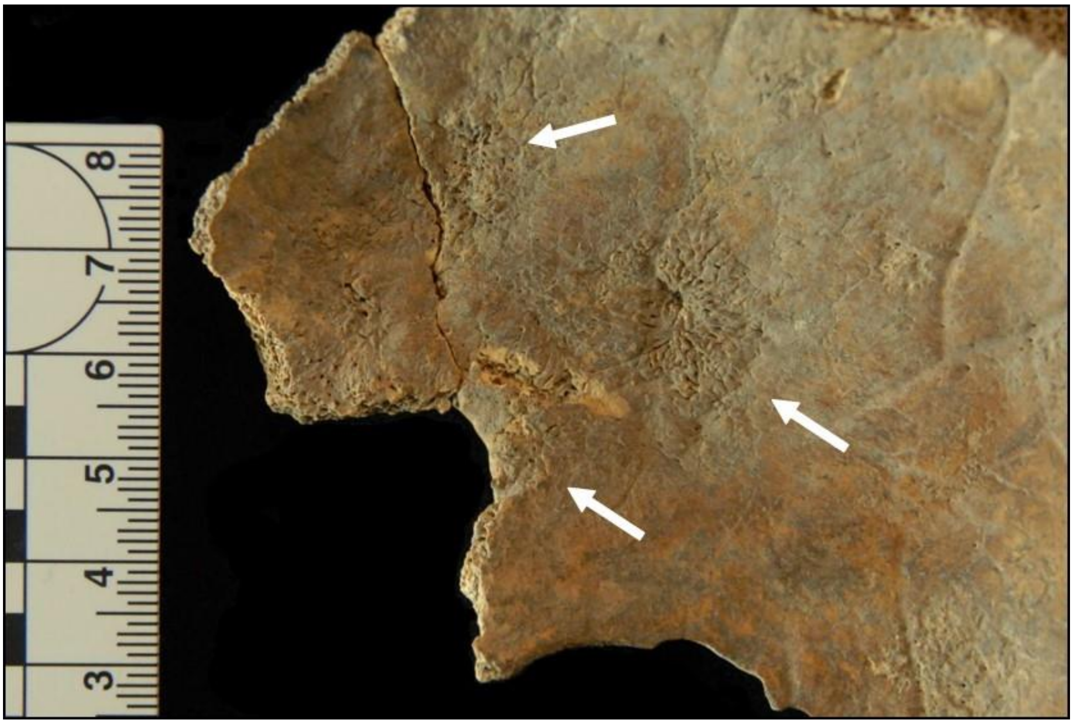

Figure 84: B110, 4180_Top – Right parietal, view of endocranial surface showing several foci of remodelled new bone deposition with labyrinthine vessel impressions, indicative of an inflammatory process (white arrows). The concentration of these foci close to the healing penetrating wound (white arrows) suggests it is likely they resulted from secondary infection associated with this injury.

5.6.2 Antemortem case study: Discussion

The presence of two different wounds, with differing degrees of healing and remodelling, suggests this individual had been subjected to at least two separate, significantly violent encounters in their past, long before the events which led to the individual's death and deposition within the medieval fortification ditch at Sidon. With regard to the open penetrating lesion of the right side of the head, the degree of healing established, with marked remodelling of the margins indicates the injury must have taken place months before the healing process ceased with the death of the individual. Survival from such a severe injury for at least long enough that the healing process had been established strongly suggests informed treatment of the wound. However, the foci of new bone with labyrinthine vessel impressions on the endocranial surface in the vicinity of the penetrating lesion (Figure 84), indicate the wound had likely become infected prior to death.

The subtle evidence of this probable sharp force cut to the back of the head is indicative of a violent injury much further back in the individual's life history, likely years before death given the remarkably advanced healing. This exceptionally well-healed injury further supports the indication that the individual had access to those with knowledge to treat such severe head wounds.

This single cranial fragment therefore serves to demonstrate the potential of fragmentary, commingled remains to inform on the lifestyles and social status of the individuals represented within such deposits whose identity has otherwise been greatly reduced or neglected as a result of their preservational state.

5.7 Isotopic Studies

The isotopic analyses carried out on samples from the human remains from burials 101 and 110 were undertaken in an attempt to investigate and potentially characterise the origins and diet of the individuals and group(s) represented. The lack of detailed strontium baseline data for Lebanon and the Levant currently hinders the ability to pose more specific questions regarding the geographic origins of the individuals from burials 101 and 110. However, the limited comparative data available do provide evidence for a general strontium and oxygen isotope signature for the region relevant to the Sidon data (see Figure 93).

5.7.1 Strontium and oxygen

Figure 85, Figure 86 and Figure 87 present the results of the strontium and oxygen isotope analyses, with initial interpretation by Dr Janet Montgomery (Durham University). The results appear to show the individuals are broadly distributed into three groups. Group 1 sits just below the marine end member signal (seawater), while the majority of group 2 cluster closely around a value of 0.7082, significantly lower than that of group 1. Group 2, including its outlier, also appears distinct from group 1, based on the oxygen isotope values. Group 3 sits above the value of the marine end member, clearly therefore differentiated from the first two groups.

The two lines representing Sidon dentine (Figure 85 and Figure 87) indicate the strontium values of the two dentine samples, which were not analysed for oxygen. These serve to suggest that the burial taphonomy has not greatly impacted the original strontium signals, although both dentine values are slightly lower than their respective enamel values, indicating there may have been some minimal leaching.

Descriptions of the individual samples are provided in APPENDIX A12: Isotope Sample Weights.

Table 14: Results of all dental enamel and dentine samples analysed for Strontium and oxygen isotopes.

Sample Code	$^{87}Sr/^{86}Sr$ norm	2 SE	$\delta^{13}C$ (‰)	$\delta^{18}O$ (‰)
SIDN101-1	0.708744	0.000073	-11.9	26.6
SIDN101-1D	0.708543	0.000063	n/a	n/a
SIDN110-1	0.709393	0.000108	-13.3	25.2
SIDN110-2	0.708228	0.000105	-12.5	27.3
SIDN110-3	0.708223	0.000069	-11.9	26.9
SIDN110-4	0.708995	0.000009	-12.2	24.8
SIDN110-5	0.709009	0.000007	-12.5	24.1
SIDN110-5D	0.708583	0.000009	n/a	n/a
SIDN110-6	0.709689	0.000008	-13.4	26.2
SIDN110-7	0.709387	0.000008	-12.4	26.4
SIDN110-8	0.708274	0.000013	-12.3	27.0

All samples funded by The Gerald Averay Wainwright Fund (Research Grant reference: AM/16) in conjunction with Dr Janet Montgomery (Durham University).

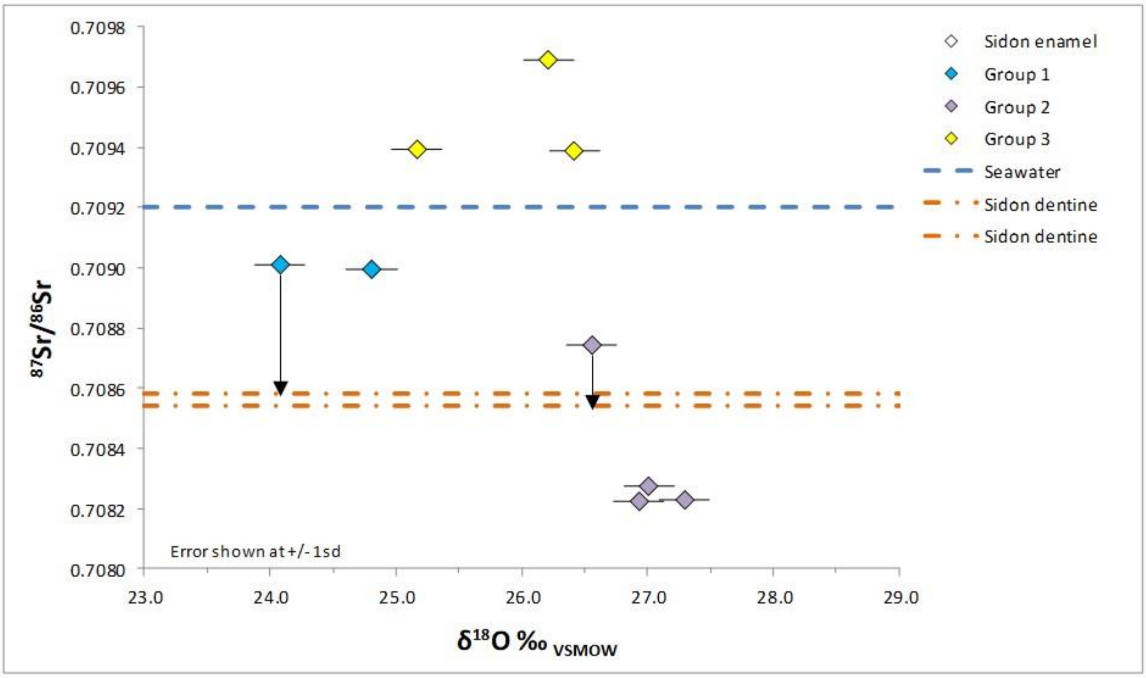

Figure 85 Results of the strontium and oxygen isotope analyses from burials 101 and 110: Strontium versus oxygen (arrows indicate enamel samples linked to dentine signals).

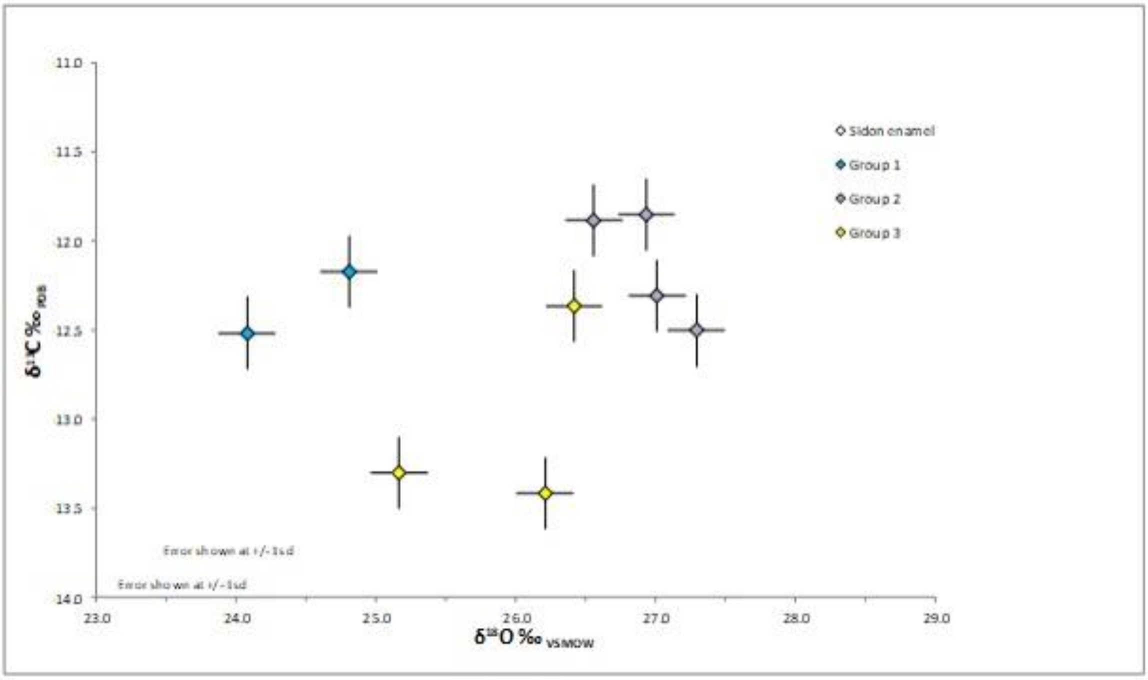

Figure 86: Results of the strontium and oxygen isotope analyses from burials 101 and 110: Carbon versus oxygen.

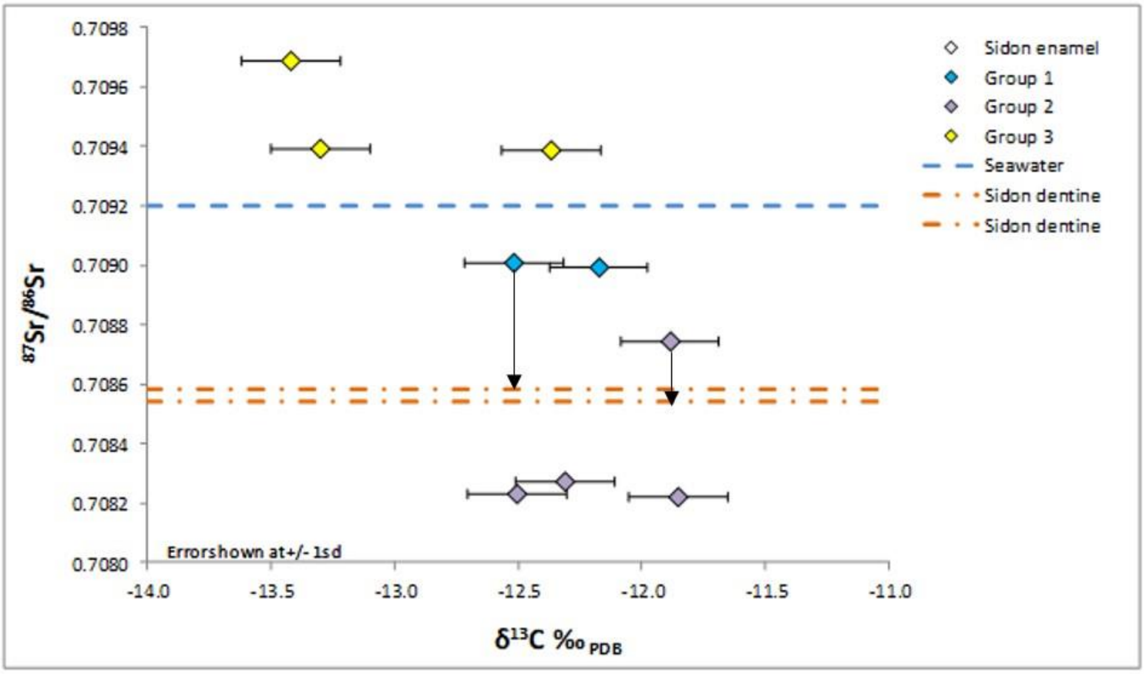

Figure 87: Results of the strontium and oxygen isotope analyses from burials 101 and 110: Strontium versus carbon (arrows indicate enamel samples linked to dentine signals).

5.7.2 Carbon and nitrogen

Table 17 presents the results of the all stable carbon and nitrogen isotope analyses. These include the data from the pilot study carried out by Dr Julia Beaumont at the University of Bradford in Summer 2016 as well the main study data produced from the analyses carried out at the National Oceanographic Centre, Southampton, in Autumn/Winter 2017. Preservation was generally poor, with the pilot study providing only a bulk value for the dietary isotopes. The carbon/nitrogen ratio for the pilot sample was outside the range for physiological values, indicating that contamination of the isotopic signature was highly likely in this instance. The results of the main study demonstrated similar issues, with over half of the remaining samples producing carbon/nitrogen ratios outside the accepted range. Figure 88 shows the plotted results of those samples for which the value lay inside the acceptable bounds.

Descriptions of the individual samples are provided in APPENDIX A12: Isotope Sample Weights.

Table 15: Results of all dietary stable isotope analyses.

Sample Code	$\delta^{15}N$ (‰)	$\delta^{13}C$ (‰)	C:N
SIDN101-3	n/a	n/a	n/a
SIDN101-4	n/a	n/a	n/a
SIDN101-5	-19.05	9.14	2.76
SIDN101-5**	-19.56	9.05	3.02
SIDN101-6	-19.68	11.22	2.99
SIDN101-7	-18.79	10.84	2.83
SIDN101-8	-18.06	10.41	2.78
SIDN101-9	-18.48	9.02	2.79
SIDN101-10	-18.56	8.36	2.77
SIDN110-5Seq[1]	-21.29	12.96	5.91
SIDN110-11	n/a	n/a	n/a
SIDN110-12	n/a	n/a	n/a
SIDN110-14	-19.01	9.4	2.8
SIDN110-15	-20.01	9.43	2.98
SIDN110-16	-19.99	7.82	3.14
SIDN110-17	-18.74	7.98	2.83
SIDN110-18	-19.39	9.36	2.95
SIDN110-19	-19.52	10.12	3.07
SIDN110-20	-19.58	12.12	2.87
SIDN110-21	-19.44	7.09	2.78
SIDN110-22	-18.43	9.82	2.92
SIDN110-23	-19.39	9.45	3.04
SIDN110-24	-18.74	9.66	2.91
SIDN110-25	-20.01	6.93	2.99
SIDN110-26	-15.68	9.97	2.8
SIDN110-27	-18.91	9.18	2.83
SIDN110-28	-19.45	10.21	3.22
SIDN110-29	-19.63	12.08	3.2
SIDN110-30	-18.69	7.72	2.9
SIDN110-31	-19.31	10.27	3.05
SIDN110-32	-19.13	9.12	2.96
SIDN110-33	-19.03	10.68	3
SIDN110-34	-18.86	10.99	2.89
SIDN110-35	-18.59	10.43	2.82
SIDN110-36	-19.07	9.64	2.99
SIDN110-37	-19.94	10.24	3.54
4247[2]	-19	11.3	3.16
4271[2]	-18.8	9.5	3.18
4301[2]	-19.2	7.9	3.16
4304[2]	-18.2	8.7	3.16

[1]Data kindly provided by Dr Julia Beaumont (University of Bradford)

[2]Data kindly provided courtesy of Dr Marc Haber, funded by the Wellcome Sanger Institute

All samples kindly funded by The Gerald Averay Wainwright Fund (Research grant reference: AM/16), except where indicated.

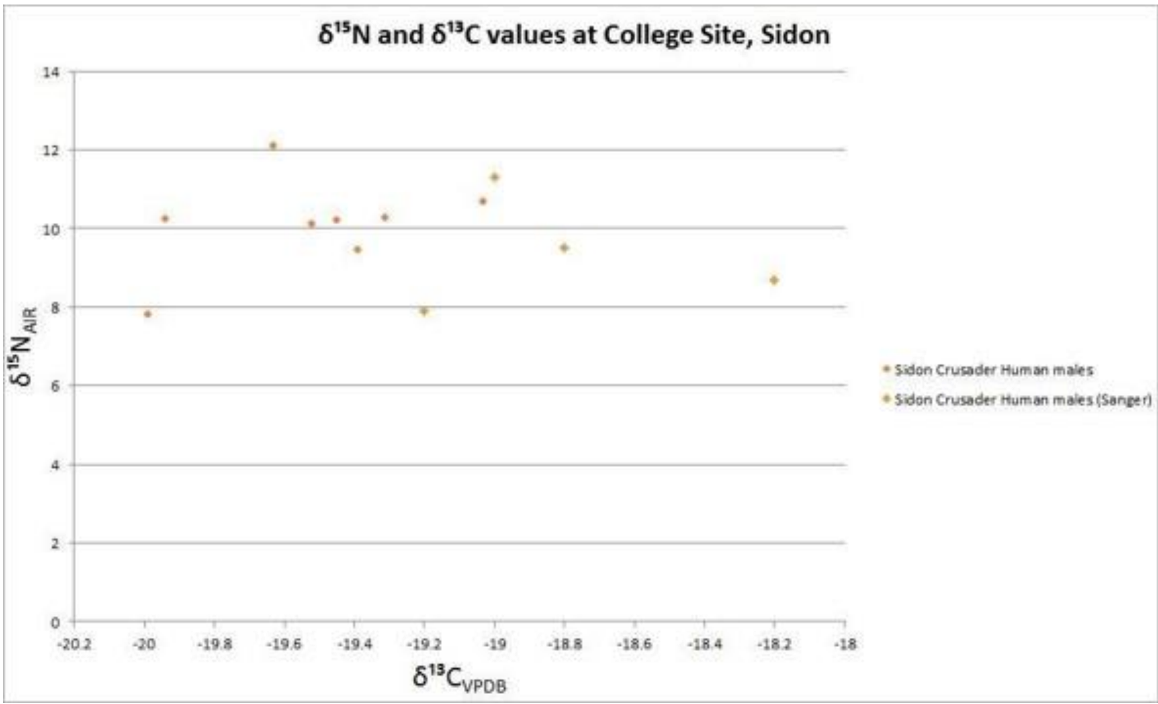

Figure 88: Results of the carbon and nitrogen stable isotope analyses from burials 101 and 110.

5.7.3 Radiocarbon dating

Table 16 presents the calibrated radiocarbon dates carried out as part of the current research, along with the previous radiocarbon date produced in 2009. Laboratory codes suffixed with * or ** indicate samples derived from the same individualised remains, one mandible from burial 101 and a second mandible from burial 110. Sample data were calibrated using CALIB REV7.0.4 software (Stuiver and Reimer, 1993; Stuiver et al., 2019).

Further details pertaining to the radiocarbon results and descriptions of the samples are provided in Table 57 (Appendix A12) and APPENDIX A13: Radiocarbon Dating

Table 16: Calibrated results of radiocarbon analyses from Sidon crusader-period human remains.

Laboratory Code	^{14}C age yr BP	95.4% (2σ) Cal age ranges	Relative area under distribution	Calibration data
UBA-33257[1]*	821±35	Cal AD 1161-1269	1.000	Reimer et al. 2013
UBA-33258[1]*	927±28	Cal AD 1028-1164	1.000	Reimer et al. 2013
UBA-33259[1]**	857±30	Cal AD 1050-1082	0.084	Reimer et al. 2013
		Cal AD 1127-1135	0.014	Reimer et al. 2013
		Cal AD 1151-1257	0.902	Reimer et al. 2013
UBA-33260[1]**	634±37	Cal AD 1285-1399	1.000	Reimer et al. 2013
UBA-36839[2]	780±35	Cal AD 1191-1283	1.000	Reimer et al. 2013
UBA-36840[2]	812±22	Cal AD 1187-1266	1.000	Reimer et al. 2013
UBA-36841[2]	774±27	Cal AD 1219-1278	1.000	Reimer et al. 2013
UBA-36842[2]	811±45	Cal AD 1058-1075	0.016	Reimer et al. 2013
		Cal AD 1154-1281	0.984	Reimer et al. 2013
UBA-36845[2]	949±29	Cal AD 1025-1154	1.000	Reimer et al. 2013

[1]Analysis kindly funded by The Gerald Averay Wainwright Fund (Research grant)

[2]Data kindly provided courtesy of Dr Marc Haber, funded by the Wellcome Sanger Institute

*/** indicate corresponding samples derived from the same individual

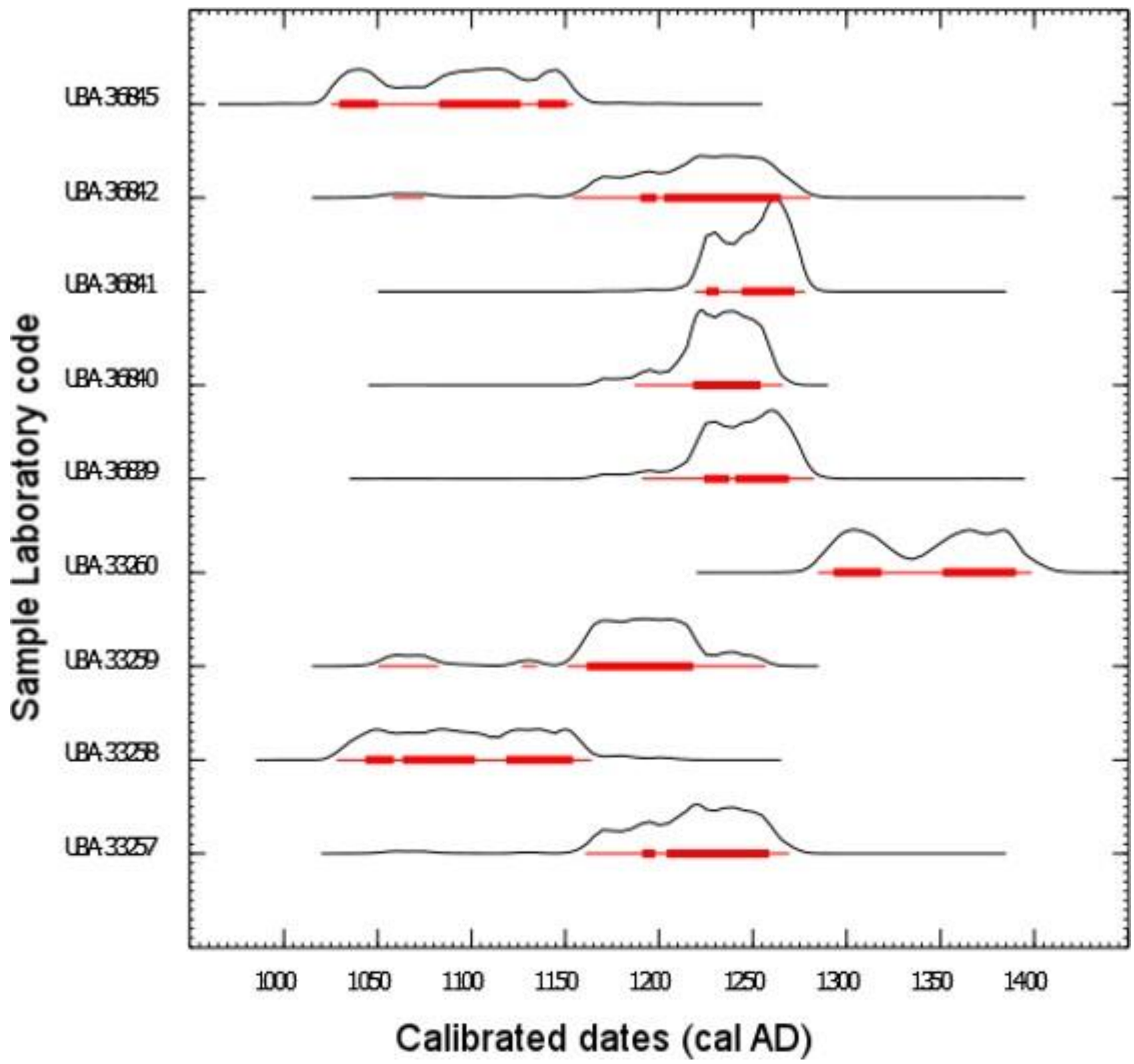

Figure 89: Posterior probability distributions for all samples derived from burials 101 and 110 at College Site, Sidon. Data for samples UBA-36839 – UBA-36845 kindly provided courtesy of Dr. Marc Haber/Wellcome Sanger Institute.

N.B. Posterior probability distribution plots (with calibration curve) for individual samples are provided in APPENDIX A13: Radiocarbon Dating.

5.7.3.1 Tests for sample significance

Using the Calib REV7.0.4 software (Stuiver and Reimer, 1993 (version 7.0.4)), tests for sample significance were carried out on multiple combinations of the calibrated results. The results of these tests are provided hereafter:

Test 1: All radiocarbon samples (including sk10153, see discussion, section 6.1.2)				
Pooled Mean	811.4547			
Square root of variance of pooled mean age	= 10.654 for 9 samples	Test statistic T	$Xi^2(.05)$	Degrees of Freedom
Conclusion	Samples are significantly different at 95% level	64.92881	15.5	8

Test 2: Samples from burials 101 and 110 only				
Pooled Mean	811.4547			
Square root of variance of pooled mean age	= 10.73259 for 8 samples	Test statistic T	$Xi^2(.05)$	Degrees of Freedom
Conclusion	Samples are significantly different at 95% level	45.14327	14.1	7

Test 3: Samples from burials 101 and 110 only (outliers excluded – see discussion, section 6.1.2)				
Pooled Mean	808.7949			
Square root of variance of pooled mean age	= 12.23939 for 6 samples	Test statistic T	$Xi^2(.05)$	Degrees of Freedom
Conclusion	Samples are statistically the same at 95% level	5.064755	11.1	5

Test 4: Sanger samples only (excluding sk10153)				
Pooled Mean	795.4157			
Square root of variance of pooled mean age	= 14.51256 for 4 samples	Test statistic T	$Xi^2(.05)$	Degrees of Freedom
Conclusion	Samples are statistically the same at 95% level	1.511318	7.81	3

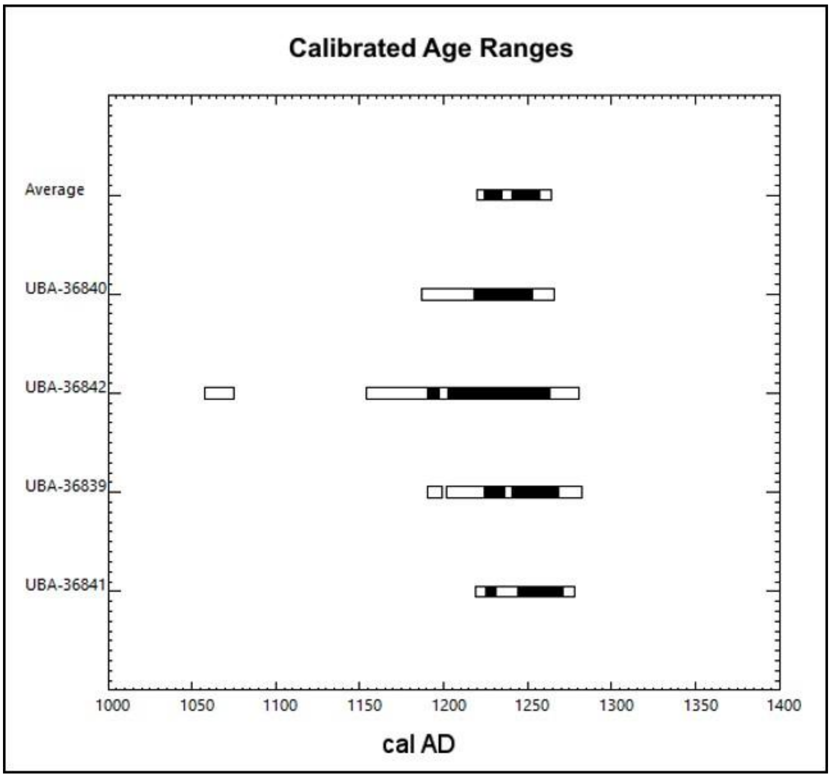

Figure 90: Block plot of all samples from burials 101 and 110 (outliers excluded) and pooled mean (top).

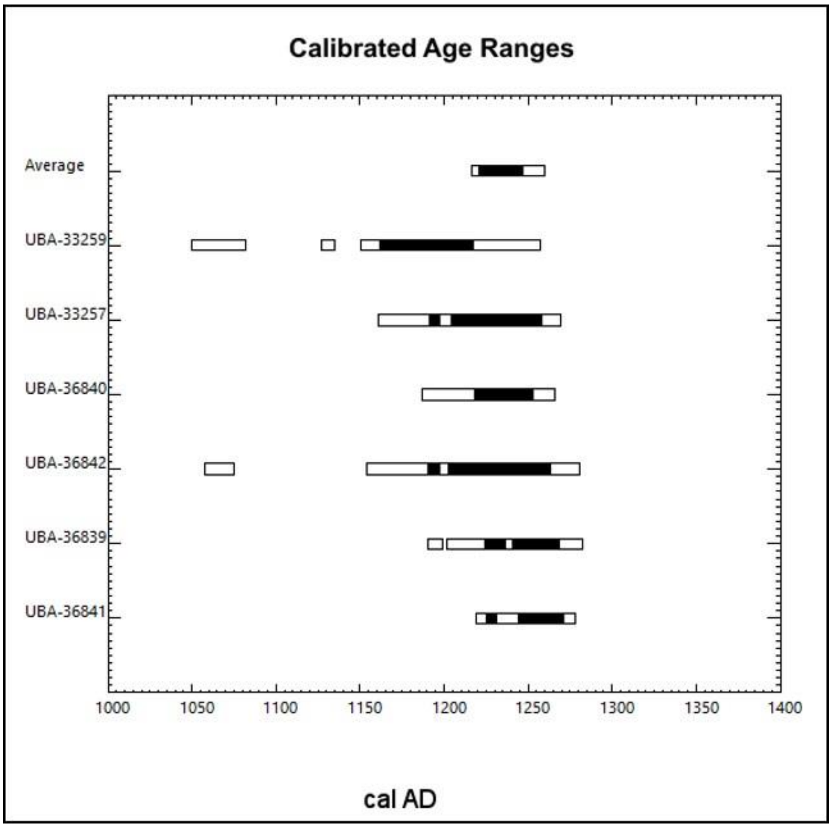

Figure 91: Block plot of Sanger samples only from burials 101 and 110 and pooled mean (top).

In the following chapter, the archaeological evidence will be discussed in the light of the radiocarbon dating, alongside the isotopic evidence and results of the trauma analysis presented in chapter four in order to integrate interpretations from the multidisciplinary research and arrive at an informed contextualisation of these significant mass grave deposits.

6 DISCUSSION

Despite the relative lack of individualisation of the skeletal remains and the only limited success in re-fitting individual sets of remains, the skeletal elements provide important insights into crusader warfare, the specific context in which the individuals met their end and the taphonomic processes and mortuary behaviour which followed in the aftermath.

6.1 The Dating Evidence

6.1.1 Dating of the deposits

On the whole, the archaeological context points to a 13th century date for the deposition of the remains within the fortification ditch. Burials 101 and 110 were clearly unrelated to the nearby Muslim cemetery, located across the modern road from College Site (see Figure 36). The two deposits were isolated and lay at a much lower stratigraphic level than the cemetery, situated between the inner (western) and outer (eastern) edges of the medieval fortification ditch (Figure 44).

Historical accounts record that the sea castle was first established in 1227-1228 by English, French and Spanish Crusaders awaiting the arrival of Frederick II during the Sixth Crusade (Eracles Text in Shirley, 1999). Following his arrival, it seems much of Frederick's time was spent in Jerusalem developing his treaty with no indication in the sources that he undertook any construction works at Sidon himself. It is possible he may have sponsored some additional work at Sidon, given his later propensity for castle building in southern Italy. However, any active re-fortification efforts had the potential to undermine his diplomatic overtures and thus on balance, it is unlikely Frederick II is directly responsible for any of the fortification features. The use of columns as headers in the northernmost block tower (Figure 41) has been attributed to the third construction/expansion phase of the castle under the Templars, dating no later than 1278 (Kalayan, 1973). However, Kennedy (1994: 122-123) prefers an earlier date for this reinforcement of the tower and suggests it is more likely the work of Simon of Montceliard during Louis IX's campaign of reparations between 1253 and 1254. Thus, if the construction technique involving the re-use of marble columns as headers can be taken as a comparative dating tool, the late medieval gateway at College Site (and potentially all the elements of the fortification ditch described in chapter 3 could be seen to be contemporary with this phase of the sea castle. If this is the case, then the construction of the former can be reasonably dated to the 13th century with a *terminus post quem* reflecting the foundation of the sea castle in 1227, as accounts indicate the Crusaders began work on the sea castle, viewing the fortification of the town as too great a task at the time. Following Kennedy, the column-header technique potentially provides a very precise date for the construction of the gateway during Louis IX's time in Sidon during the final period of the Seventh Crusade.

It is certainly feasible the features of the gateway and the ditch were constructed during Louis IX's re-fortification works, either before or after the Mamlūk raid. However, the extant accounts indicate the Crusaders had barely commenced work when the attack took place. If the majority of works took place after the raid, then it seems somewhat counter-productive to bury bodies within the ditch, having only just cleared it out. Equally, to clear the ditch when a large number of bodies have only just been collected and deposited within it seems neither preferable nor in keeping with Louis' reported reverence for the remains (Joinville, [§582], in Smith, 2008: 291).

Concerning the medieval deposits within the fortification ditch, a radiocarbon date produced from a sample from one of the animal skeletons gave a calibrated date of 1170-1263 (Doumet-Serhal, 2016: 9-10, Fig. 5a). A single early Islamic copper coin was also recovered and most likely represents a remnant of an earlier deposit. Found directly beneath the remains of a juvenile horse it has been tentatively identified as likely "*… an anonymous issue belonging to an early Umayyad period, namely around 696/9-720 AD.*" (Doumet-Serhal, 2016: 10). Other than this, Doumet-Serhal describes these late medieval deposits as relatively sterile despite expectations concerning the volume of refuse normally accumulating within such large urban cut features.

More immediate to the context of the mass grave deposits, the finds accompanying the remains provide additional indications of their dating. Whilst it may appear problematic on first inspection, in all likelihood the Late Iron Age pottery and broken lion figurine from burial 110 represent material re-deposited within burial 110 as it was back-filled, most likely with part of the earth removed to create the pit. Burial 110 had clearly cut into the western edge of a much earlier deposit of late iron age storage vessels, as shown by the open void in the base of the southeast corner of the pit (Figure 61), which represents the lower half of one of these vessels, whose top was truncated by the digging of the grave. It is also possible the copper alloy leaf-shaped arrowhead represents another incidental inclusion in the grave fill, likely disturbed during the digging of the grave cut.

The arrowhead is, however, ambiguous. Arrowheads were most commonly manufactured in iron and with a tang during the Medieval period as represented by archaeological finds in both western Europe (Jessop, 1996) and the Near East (Ashkenazi, 2012; Mitchell et al., 2006; Török et al., 2016) with its hardness proving more effective against armoured opponents. Copper alloy examples have been attributed to the Late Medieval period (Clark, 2014) and even the post-medieval period in England, but interpretation is not always reliable given that many reported arrowhead finds are without a well-documented, stratified and dated context. The possibility remains that the arrowhead may alternatively date to either the Roman period, the Iron Age or even earlier and thus potentially represents a further incidental inclusion. Regarding the iron nails and the tacks recovered from burial 110, similar examples of both have been reported in significant numbers at the site of Al-Burj al-Ahmar, with the majority recovered from 13th century deposits (Pringle, 1986: 168-170).

Perhaps the most significant dating evidence from the artefacts is the base silver coin recovered from near the top of the centre of burial 110. In their description of this coin, Moorhead and Cook (2012: 404) provide a tentative *terminus post quem* of 1245 for the deposition of the remains within the pit of burial 110. This was the only coin found directly associated with the remains. It is therefore possible that, being located at the top of the deposit, the coin may have been deposited subsequent to the deposition of the human remains, potentially much later, with its association possibly coincidental. However, this may be rather too cautious an interpretation, particularly given the lack of other coins closely associated with these mass grave deposits; an alternative explanation for the coin's isolation with the remains is suggested in the taphonomy discussion towards the end of this chapter.

6.1.2 Radiocarbon dating of the human remains

On the whole, the radiocarbon results from the human remains (including both those dates funded by the Gerald Averay Wainwright Research Grant and those commissioned by the Sanger Institute as part of the DNA research (Haber et al., 2019) confirm the initial radiocarbon date derived from the superficial layer of burial 110 (Collins, 2012: 418), with all samples demonstrating at least some overlap with the crusader period. Only two samples demonstrated no overlap with the 13th century (Figure 92). These included a dentine sample (UBA-33258) from burial 101 and the cranial bone sample (UBA-36845) taken from the isolated cranium (context 10153), found close to the inner edge of the fortification ditch (i.e. at the base of the interpreted round tower, represented by wall 9078).

Deriving from context 4147, part of burial 101, the outlying dentine sample is more problematic. This sample was one of two taken from context 4147 for radiocarbon dating, with both the mandibular left M1 and mandibular left M3 sampled in an attempt to gain as precise a date as possible for the individual's remains, following Millard (2015). These two samples derived from the same side of the same mandible, yet the later developing tooth was indicated to be older than its developmental precedent. The M1 sample (UBA-33257) gives a date more in keeping with the mid-13th century trend, yet the M3 sample (UBA-33258) produced a considerably older date range. Furthermore, the two teeth demonstrate only three years of overlap between their posterior probability distributions (see Table 16 and Figure 89). It is generally accepted that there is a development interval of approximately ten years between the first and third molar teeth (AlQahtani et al., 2010; Millard, 2015). The samples were taken from approximately the same region, the upper root dentine and in theory together they should demonstrate an overlap of at least ten years.

As described in the trauma results (see Section 5.4), context 4147 represents the most complete individualised set of remains recovered from either of the two mass grave deposits. If these remains date to the 11th or 12th century, it is highly unlikely they would have retained such an advanced degree of articulation relative to all other remains within the two deposits, which the majority of the samples indicate date to the early to mid-13th century. It seems more likely then that contamination of the sample is the cause of such an early date relative to most of the other samples. Contamination or mixing can occur via several different mechanisms: it can be intrinsic and begin even before the individual's death due to the laying down and remodelling of secondary dentine within the tooth root itself; samples may become contaminated within the burial matrix due to taphonomic conditions; finally, contamination may also potentially occur during the sampling process itself. Context 4147 also underwent strontium analysis, with both dentine and enamel sampled from the same tooth. The results demonstrated a reduced strontium signal in the dentine that was also observed in the only other tooth that was similarly sampled from both constituent materials (see Figure 85). It is possible therefore the strontium results indicate tooth dentine was susceptible to extrinsic influences on its mineral content. In this case, the ambiguous radiocarbon analyses from context 4147 might best be explained by contaminating influences deriving from the burial environment if not the burial matrix itself. Given the earlier date deriving from the third molar of context 4147, it is suggested the source of contamination, if confirmed, derives from the earlier sediments or deposits included in the burial matrix of burial 101.

The remaining two radiocarbon samples deriving from tooth dentine (UBA-33259 and UBA-33260) also demonstrate interpretive ambiguities. Again, both samples derive from the same individual (represented by the M1 and M3 teeth from a right mandible derived from grid/layer context 4203_H_L6) and despite both producing date ranges overlapping with the 13th century, they demonstrate no overlap between their posterior probability distributions at all. Once more, extrinsic contamination is suggested as it seems unlikely that intrinsic mixing due to secondary dentine deposition and remodelling would account for such large age ranges and for the substantial interval between them.

A test for sample significance was carried out using the Calib REV7.04 software (Stuiver et al., 2019). Results of the T-test showed that the samples are significantly different at the 95% level (Test statistic T = 64.92881; $\chi 2$ (.05) = 15.5; degrees of freedom = 8) and demonstrates the radiocarbon dates from the human remains form at least two distinct groups (see Figure 92). However, if we exclude the outlying results from the dentine samples above (UBA-33258 and UBA- 33260), a separate T-test confirms the vast majority of the samples from burials 101 and 110 clustering around the early to mid-13th century are statistically the same (Test statistic T = 5.064755; Xi2(.05) = 11.1; degrees of freedom = 7). This 13th century trend fits well with both the original radiocarbon date carried out (1160 – 1256 cal AD (95.4%) – see Collins, 2012: 418) and the date produced by the articulated animal skeleton found close to the gateway area just south of burials 101 and 110 (1170 – 1263 cal AD (95.4%) in Doumet-Serhal, 2016: 9-10).

In contrast, context 10153, the isolated head from the inner side of the ditch, is clearly distinct and dates somewhere between the mid-11th and the mid-12th century (Figure 92). These cranial remains may therefore relate to one of the two sieges of Sidon undertaken by Baldwin I, which preceded Sidon falling into the Crusaders' possession for the first time in 1110 (see Figure 5). The association of the articulated cervical vertebrae and mandibular fragment indicate the presence of soft tissues at the time of deposition, suggesting several scenarios for the incorporation of the head in its final location. The head may have been curated in some way prior to deposition, perhaps used as a symbolic decoration upon the town walls or the tower itself; it is also possible it may have been removed or disturbed from another separate burial context (although the presence of the articulating elements would point to the disturbance of a relatively contemporary burial). A further alternative explanation is that the head, having already been separated from its owner, was deliberately projected at the town using a siege machine of some sort, failing to surmount the town's fortifications and coming to rest at the base of the tower. In all three instances, it is suggested the remains could easily have become covered in sediment rapidly at the edge of the ditch where refuse and debris would also likely have built up rapidly in a colluvial manner.

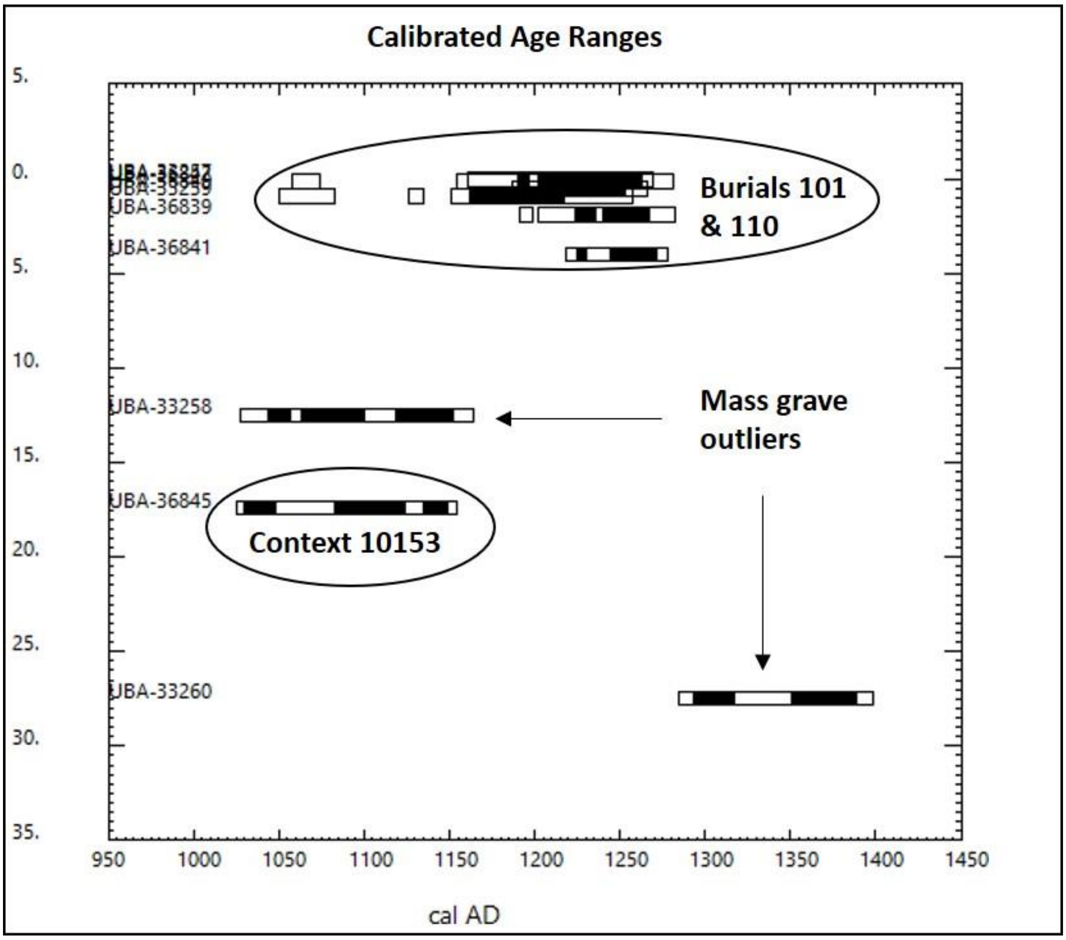

Figure 92: Results of the initial T-Test on the probability distributions of the radiocarbon dates from all human remains from the Medieval fortification ditch (produced using Calib 7.1 software, following Ward and Wilson, 1978).

Concerning the dating of the mass grave deposits, the majority of the remains from burials 101 and 110 represented adults, although at least two older adolescents were also present. We might therefore anticipate a lag between the acceptable dentine sample dates (i.e. the times at which they were originally laid down, assuming they represent primary dentine) and the deaths of the individuals to which they belong. Similarly, the cranial bone sample dates might well represent bone laid down or remodelled some considerable time prior to the time of death. Therefore, we might reasonably place the actual time of death (and deposition) closer to the later, mid-13th century end of the grouped posterior probability distributions (Figure 92).

All this points to a high probability that the event which led to the deaths of these individuals, the creation of the pit and the deposition of the remains within and alongside it, was the Mamlūk raid in the Summer of 1253. However, the nature of the radiocarbon dating and the lack of a convenient *terminus ante quem* means that the Mongol assault on the town in 1260 cannot be ruled out. Although the coin provides relatively good dating evidence, its position towards the top of burial 110 potentially undermines its validity as a *terminus post quem*, thereby leaving open the possibility that these deposits date to sometime in the earlier half of the 13th century.

6.1.3 Primary vs secondary deposition?

Several lines of evidence clearly indicate the human remains from both mass grave contexts at Sidon are secondary in nature. Most obviously, the significant numbers of disarticulated elements and the presence of incomplete individuals points to disruption of the original depositional context. There was no evidence of truncation by overlying deposits or any other intrusive disturbance of the grave prior to excavation. There was little indication of any substantial settling of the remains in either deposit and no evidence of complete individuals having become dissociated following deposition. It is therefore clear the human remains were deposited into the grave or placed beside it in the state described at the time of excavation. Furthermore, the presence of weathering on some elements (e.g. Figure 104) indicates at least some remains had been left unburied for some time prior to inclusion within burial 110. The separate locations of two fitted femoral fragments with contiguous weathering also represents clear evidence of the remains' secondary deposition.

Some insight into the time interval between initial deposition (i.e. the time of death) and inclusion within the secondary mass grave deposits is also possible. The presence of partially articulated remains and articulated groups of elements clearly representing body parts or sections (e.g. contexts 4147, 4213, 4247), along with the potential presence of decomposition insects (suggested by the partial fly pupal impression – see Figure 53) provides strong indication that the remains had partially but not fully decomposed prior to collection and deposition within and alongside the grave. The rate of decomposition would have varied depending on ambient temperature, season and other environmental conditions, but the presence of soft tissue at the time of deposition is clear in both burials 101 and 110. Supporting this, amongst the burnt bone there are also indicators for the presence of fleshed remains within the grave.

6.2 The Social Context

6.2.1 The Victims

6.2.1.1 Identity/ethnicity

The overall numbers of differing bone elements were relatively consistent, given the interpretation of burials 101 and 110 as secondary depositions following exposure of the remains with at least partial decomposition having taken place.

The demographic profile fits well with the context of inter-group violence and is similar to that demonstrated for other mass graves associated with warfare, both during the Medieval period (Boucherie et al., 2017; Boylston et al., 2007; Kjellström, 2005; Loe et al., 2014; Štefan et al., 2016) and in early and later modern contexts (Gaudio et al., 2015; Loe et al., 2013; Nicklisch et al., 2017; Pfeiffer and Williamson, 1991; Sciulli and Gramly, 1989; Signoli et al., 2004). The presence of a minimum of two subadults present, both older adolescents, with the rest of the remains able to be aged indicating individuals ranging from young adulthood to middle age, is again clearly in line with other mass graves resulting from the contexts referenced above. The lack of any clear indication of females, along with the presence of recidivists, is typical of groups associated with conflict-related mass grave sites (e.g. Nicklisch et al., 2017; Novak, 2007; cf. Grainger et al., 2008), although the regular violence of the Crusader period, as described in the historical records, means we cannot be certain these individuals were trained and experienced soldiers.

This profile may fit well with the Crusaders' sieges of the town at the beginning of the 12th century, yet there is little indication from the records that these sieges were particularly bloody affairs, excepting the possible association of the isolated cranium within the ditch. The dating and nature of the cultural material directly associated with the remains from burials 101 and 110 (i.e. the Frankish buckles and the silver *denaro*) strongly suggest they represent crusader forces, whether newly arrived westerners or second or later generation settled immigrants.

The best historical account we have for the Mamlūk raid in 1253 reports that Sidon was undergoing a major programme of refortification and reparative works focussed on the city's walls and strongholds (Joinville, [§551] in Smith, 2008: 282). The population at this time would therefore have been swollen by an influx of labourers and specialist stone masons brought in for the construction works, and it seems likely that some of these fell victim to the Mamlūk assault, especially if we take the casualty numbers reported to be genuine.

However, stone masons and other skilled specialists represented important resources valued by both Christian and Muslim authorities and were more likely to be taken alive and their skills taken advantage of, as indicated in the Eracles text (Bk 34, Ch.2 (1250-1254), Eracles Continuation in Shirley, 1999: 139).

Details regarding Sidon's population in 1260, when a Mongol army sacked the town, are not known, although evidently there were enough people to warrant evacuation to both the castles and to the offshore island of Ziri for shelter, and it is assumed these represented a mix of local residents and multiple generations of settled Franks as well as perhaps some itinerants such as merchants and pilgrims.

Concerning the isotopic evidence, despite being a limited sample, the results of the strontium and oxygen isotopes from the crusader human remains indicated the individuals analysed could be separated into three different groups (see Figure 93 and Strontium and oxygen). Two of these groups (groups one and three, representing a total of six individuals) produced strontium signals lower to that of the seawater signal, but were differentiated by their oxygen isotopes. Group one, consisting of two individuals, demonstrated an oxygen signal lower than group three. The interpretation of group three is rather ambiguous, but the reduced strontium isotopic content compared to seawater suggests they are more likely locals, whilst the difference in oxygen could potentially indicate the two groups originated in areas or regions with slightly different climates or, alternatively, the two groups differed in their cultural practices such as cooking. Group two consisted of three individuals with strontium results above the seawater signal. These individuals are currently considered to be non-locals who grew up elsewhere, in a location with geology different to that of Sidon. Group three, consisted of four individuals with markedly lower strontium isotope levels compared to the other two groups.

Three of these individuals formed a very tight cluster, with the fourth (context 4147, see Section 5.4) producing a noticeably higher strontium signal but was still most closely associated with the group. Group three is considered most likely to represent local residents who had grown up in this region of the Near East.

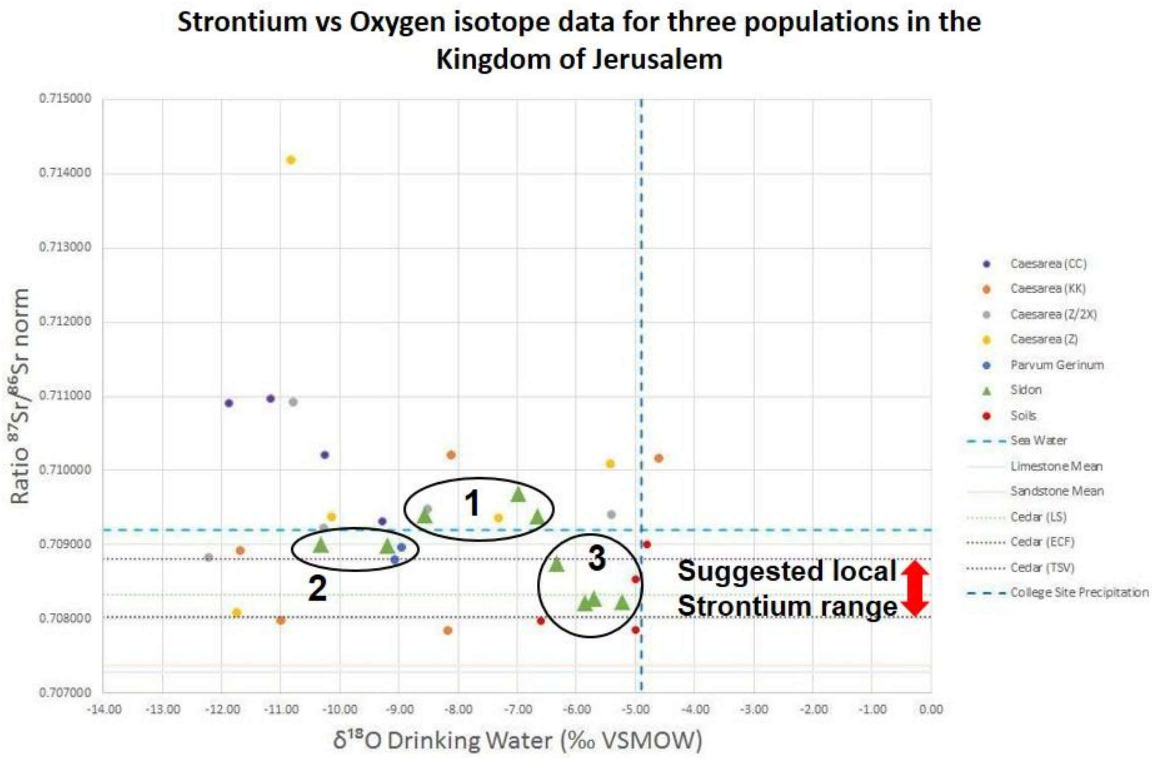

Figure 93: Strontium vs Oxygen data for three populations in the Kingdom of Jerusalem, with Sidon groupings indicated. Sources: Data for Caesarea and Parvum Gerinum taken from Mitchell and Millard (2009); data for local environmental strontium taken from Rich et al. (2015); College Site precipitation (Mean Annual) based on data for modern δ^{18}O Drinking water calculated using the Online isotopes in precipitation calculator (OIPC), version 3.1 (Bowen, 2019), following Bowen and Revenaugh (2003), data source: IAEA/WMO (2015).

This interpretation is supported by local environmental data reported by Rich et al. (2016), with all four of the individuals from group three sitting within the bounds of the suggested regional strontium ground signature variation for Lebanon. This data also supports the interpretation that the group one individuals represent a second group of non-locals, likely from a different locale to that of group two. However, further work is needed to develop detailed and reliable baseline isotopic data for the region, with particular reference to clarification of the strontium signature and its variability along the coastal region of Lebanon and the southern Levant.

If we consider the oxygen isotope data, estimates for the δ^{18}O of modern drinking water based on data provided for the locality of Sidon, Lebanon (defined by latitude, 33°, longitude, 35°, altitude, 0 m) indicate an expected modern signature of -4.9‰ VSMOW (Bowen, 2019; Bowen and Revenaugh, 2003; IAEA/WMO, 2015). This is a little higher than the local group (group three), although some variation in the climate is unsurprising given the time interval since the Late Medieval period.

Group three is, however, bracketed by the soil oxygen isotope data from Mitchell and Millard's (2009) study which looked at samples from approximately 111 to 123 km further south along the Levantine coast, adding further support to their interpretation as locals. Again, all the remaining Sidon individuals from groups one and two appear to be excluded by the extant soil data, producing lower oxygen isotope signatures than the indicated local signature for the Levantine coast. Clearly, then, there is strong evidence to suggest the Sidon dead were a mixed group consisting of individuals representing at least two, if not three communities originating from differing regions, one of which was most likely local to Sidon.

Recent DNA analyses have provided further support for the results and interpretations concerning both the demography and the diverse origins of the group and their relative mobility. These results confirm male sex for all individuals sampled from burials 101 and 110 (n = 8) and demonstrate a mixed group with diverse ancestries that can also be loosely categorised into three communities: one of recent European ancestry, one of local Lebanese ancestry and one group of two individuals with mixed ancestries (Haber et al., 2019).

The dietary isotope data indicates the Sidon dead demonstrate a relatively similar diet across the group (Figure 94), that is also consistent with the dietary signal reported for the Middle Bronze Age population at Sidon (Schutkowski and Ogden, 2012), albeit with slightly higher nitrogen signals in general, suggesting perhaps slightly more protein in the diet.

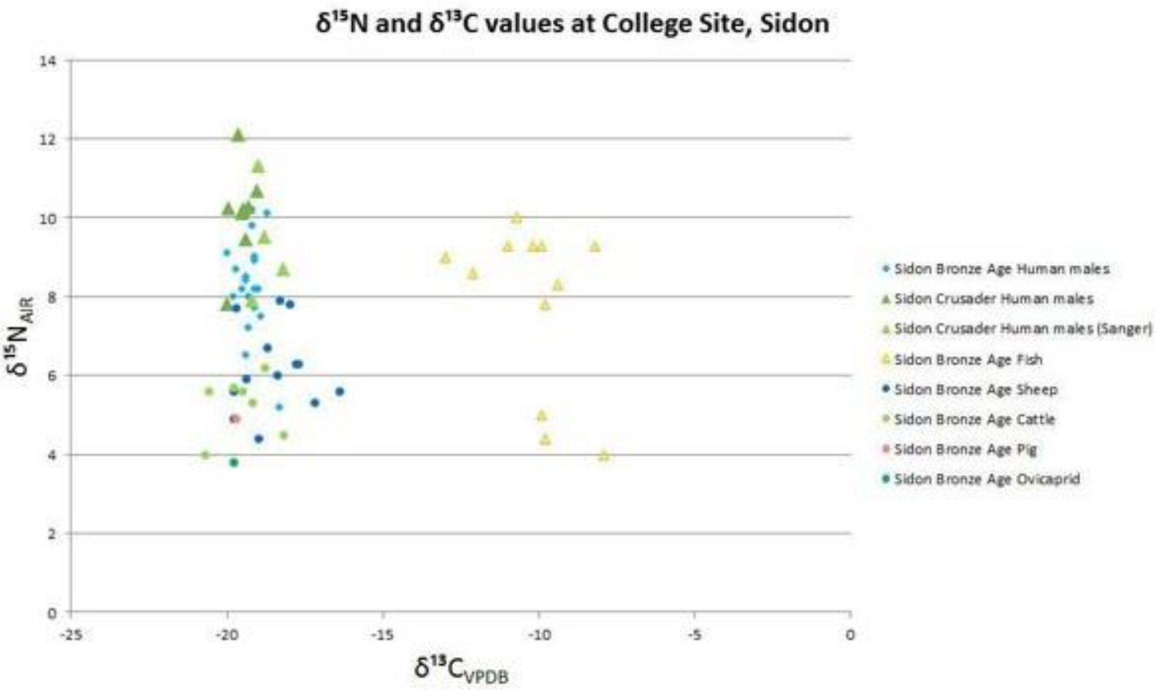

Figure 94: Dietary isotope results of the Crusader human samples plotted against the Bronze Age human, animal and fish samples. Source: Schutkowski and Ogden, 2012.

For both periods, a distinct lack or even absence of fish in the Sidon diet is indicated which is surprising given the city's coastal location. For the Bronze Age, this appears to contrast with the contemporary archaeological and funerary evidence for fishing practices (Chahoud and Vila, 2012: 274-275; Doumet-Serhal, 2013: 81) and the results are certainly unexpected placed alongside the historical traditions for western medieval diet at least. Furthermore, the medieval Muslim writer al-Idrīsī mentions "*… a celebrated spring…*" at Sidon, reporting that this was a seasonal breeding place for a particular type of small fish in the Spring months; the dried fish being revered as an aphrodisiac (Le Strange, 1890: 346-347).

A single late medieval individual (context 4304) demonstrated a slightly elevated stable carbon signal suggesting fish may have formed at least a small part of their diet. However, this sample consisted of dentine and therefore may have been subjected to post-depositional contamination as indicated by the differences between the tooth enamel and tooth dentine sampled for strontium (see sections 5.7.1 and 6.1.2) and the poor preservation of collagen observed in the majority of the dietary isotope samples (see Carbon and nitrogen). Worth noting here is the publication of multiple studies suggesting that some dietary components may drown out other component signals (e.g. Goude et al., 2017), with Naito et al. (2013) proposing new methods for distinguishing between terrestrial and aquatic resource consumption in human diet.

6.2.1.2 Group characterisation

In summary, the individuals from burials 101 and 110 likely constitute a mixed group of individuals, with both locals and non-locals represented, who lived at some time between the late 12th century and the first half of the 13th century. Additional observations and interpretational details concerning identity are included in the following sections.

6.2.2 The Assailants

Evidence for the identity of the assailants responsible for inflicting the trauma observed in the individuals from burials 101 and 110 is limited. Yet there are clear suggestions deriving from both the historical evidence and interpretation of the trauma patterning with which each align well.

6.2.2.1 The Evidence for military training

Contamine (1984: 258) uses contemporary records of losses in late medieval battles to support his argument that full-scale 'true' battles were in fact rare occurrences, with competing forces and needless-to-say the individuals of which they were made up, generally reluctant to commit to situations in which the risk of death was high. Consequent to this, he states that "*… many soldiers, even professionals at the end of a long military career, had only experienced one or two* ['true' battles]". This reluctance to commit to open battle appears in the Near East also, as evidenced in 1187 by the preference of the majority of Saladin's advisors for weakening the Franks with repeated raiding and small-scale assaults (Ibn Al-Athīr, XI, 351-5, in Gabrieli, 1984: 119).

This cautious reluctance to engage in full-scale battle might be used to suggest a lack of individuals experienced in close-quarter fighting. Yet there were clearly individuals and groups with professional military expertise. On the Frankish side, evidence of the skills and experience of the members of the Military Orders comes from their treatment as prisoners. Saladin's selective execution of the Templars and Hospitallers taken prisoner at Hattin demonstrates his strategy/need to weaken the Frankish States through diminution of their most effective defence forces. Indeed, Ibn Al-Athīr is explicit in stating: "*He* [Saladin] *had these particular men killed because they were the fiercest of all the Frankish warriors,…*" (Ibn Al-Athīr, XI, 351-5 in Gabrieli, 1984: 124).

Regarding the Muslim troops, military prowess, especially concerning horsemanship, became increasingly socially significant from the end of the early Islamic period onwards at least, as represented by the increasing prominence and variety in the developing furūsiyya literature. The second treatise attributed to the ʻAbbāsid general, Ibn Akhī Ḥizām Muḥammad ibn Ya'qūb al-Khuttalī, who died towards the end of the ninth century, constitutes a detailed military training manual. Though evidently predating the crusader period by at least two hundred years, Al-Sarraf describes it as "*…the main source of future treatises…*" (Al-Sarraf, 2002: 168). Ibn Akhī Ḥizām provides specific detail on mounted battle training, particularly pertinent to interpretation of the cervical trauma observed at Sidon:

> *"A green reed should be firmly fixed to the ground at the height of the rider. The horseman should approach it from the right-hand side at full gallop, just like when he is training to shoot from horseback. When he gets close to it he should, with one swift movement, draw his sword and strike the reed from right to left, cutting [off] the equivalent of one [hand] span. The same movement should be repeated until only one dhirā' [approximately 50cm] is left of the reed.*
>
> *The whole exercise should be repeated again and again until it is perfectly mastered. When that is done, five arrows should be planted in line at a distance of 10 dhirā' (approximately 5 m] from each other. The horseman, at full gallop, should in one run cut the arrows exactly at the same height, one after the other just beneath the fletching using a very sharp-edged sword.*
>
> *When this is perfectly mastered, two parallel but staggered rows of five arrows each should be planted in the ground. The horseman, again at full gallop, should run between the two rows of arrows cutting them under the fletching as in the previous exercise, striking alternatively to the right and to the left…When this is also perfectly mastered, the horseman should be trained to deal blows in all other directions."*

(Ibn Akhī Ḥizām, al-Kamāl fi'l-furūsiyya…(added title), Istanbul, Fāteḥ Mosque Library, inv. No. 3513, fols.70a-b in Al-Sarraf, 2002: 168)

This description of eastern military training demonstrates clear parallels with the trauma identified amongst the Sidon Crusaders. Mounted riders, wielding either double-edged swords or sabres would be well positioned to deliver accurate, heavy cuts to the back, shoulders, neck and head of any unfortunate souls who were caught unawares; and it is certainly not difficult to imagine Ibn Akhī Ḥizām's reeds replaced by the Crusaders. The emphasis on regular military training, particularly with regard to horsemanship, is clear and this tradition became one of the foundations of the Mamlūk armies, who eventually drove the western Christians out of the Levant.

6.2.3 Historical links

In general, the dating evidence from burials 101 and 110 strongly indicates that these deposits cannot be attributed to the initial sieges carried out at Sidon in 1108 and 1110. Little if any information regarding casualties is provided in the historical sources for these specific sieges, and we cannot be certain how much actual fighting took place, although the reports of the use of siege engines during the 1110 siege suggest at least a minimal amount of aggression. The accounts record that Sidon's inhabitants eventually surrendered the city after a siege lasting forty-seven days, ostensibly at least under peaceful terms, with Muslim residents permitted to leave with their belongings. There is no written evidence indicating the burial of dead from any physical engagements.

The evidence of stone trebuchet projectiles within the ditch at College Site certainly indicates a siege situation at some point. However, their size is possibly too large and heavy for early catapults such as mangonels and traction catapults, and counterweight trebuchets only became widespread from the late 12th century onwards, although Chevedden (2000) argues they must have developed somewhere earlier. It seems most likely then that these objects date from a later period or at least were re-deposited within the cut inside the ditch at a later time period than the initial sieges at the beginning of the 12th century.

Łukasik et al. (2019: 289) have suggested that high prevalences of violent peri-mortem trauma to the head relative to the postcranial skeleton may be indicative of mounted assailants, where the context allows. Like the Swedish army of the 17th century, cavalry formed a major contingent of the Muslim armies throughout the crusader period in the Latin East. By the time of the founding of the Mamlūk Sultanate in the mid-13th century, military training and especially horsemanship with its many and varied skills had become integral to the Mamlūk army.

Yet, the head is a natural target due to strategic and psychological factors influencing assailants' motivation and actions to disable opponents from a fight (Fibiger et al., 2013). As such, a focus on the head and upper torso may well manifest in several different contexts including punitive (i.e. execution) situations as interpreted at Ridgeway Hill (Loe et al, 2014) and may occur whether assailants are mounted or not.

Joinville ([§551-552], tr. Smith, 2008: 282) reported 2,000 dead following the Mamlūk raid on Sidon in 1253, yet the Eracles Continuation provides alternative figures, reporting 800 or more men killed, with a further 400 or more taken prisoner. These latter included at least some of the masons engaged in the reparative works (Bk 34, Ch.2 (1250-1254), Eracles Continuation in Shirley, 1999: 139). Even if the discrepancies in the casualty numbers given are put aside, clearly burials 101 and 110 represent only a small fraction of those who died in this event if the records are to be relied upon.

There are also some intriguing coincidences observable within the iconographic evidence. The depiction of King Louis IX helping to bury the dead from Jean Pucelle's *Book of Hours for Jeanne d'Evreux* (see Figure 7), depicts a structure in the background which appears to represent a gateway or entrance structure. Even though this image and the book it is contained within was produced over seventy years later than the event described here, it is quite possible this represents an interpretation of an oral tradition, possibly provided by Joinville himself who completed his *Life of Saint Louis* approximately sixteen years earlier. The suggestion of a gateway close to where Louis collected and/or buried remains of the slain Crusaders is reiterated in another image, this time dating the 15th century (Figure 95 overleaf).

This image depicts specific details which align well with the archaeological evidence relating to burials 101 and 110. Not only does it show a fortified gateway in proximity to the site of burial (as well as another gateway further away), but the King and attendants are shown to be burying the remains within a rectangular pit, situated in front of a round tower.

Figure 95: A Mid-15th century illustration depicting Louis IX helping to bury the dead at Sidon. Les Grandes Chroniques de France, mid-15th century. National Library of Russia, St. Petersburg. Ms. f.338.

It is difficult to completely discount the Mongol sacking of Sidon in 1260 as the causal event leading to the deposition of burials 101 and 110. Although some of the radiocarbon dates do exclude this date, others provide date ranges spanning a larger part of the second half of the 13th century. The silver coin may only provide a *terminus post quem* for deposition of the burials (although a caveat remains concerning its position at the top of the deposit within burial 110). The accounts suggest this Mongol assault resulted in fewer casualties than that of the Mamlūks seven years previously, with many inhabitants having found shelter in either of the two castles or having been evacuated from the town courtesy of the timely intervention of two Genoese galleys. Indeed, the main focus of the Mongols' aggression appears to have been the town's fabric itself, resulting in such destruction it seems that Julian I Grenier was subsequently forced to sell the town to the Templars ('Templar of Tyre', [§303] tr. Crawford, 2003: 35; Jackson, 1980: 499-500).

6.3 The Skeletal Trauma

There is evidence of three separate categories of peri-mortem trauma within the human skeletal remains from burials 101 and 110. These include bony lesions, often with smooth or 'polished' surfaces remaining, indicative of blade injuries; at least one well-defined, angular perforation suggestive of either a projectile injury or a well-focussed penetrating wound from a pointed object; and the blunt force trauma evidenced by bony lesions exhibiting characteristics including plastic deformation, crushing, hinged fragments, associated bone 'tear' and incomplete fractures as well as smooth and stained fracture surfaces and bevelled fracture angles.

Sharp force lesions were most easily confirmed, where their fracture characteristics included sharp fracture margins with well-defined edges and smooth, polished cortical bone surfaces. As highlighted previously, such fractures and their characteristics do not manifest with organic in vivo pathology and are highly unlikely to be produced in the post-mortem period once the bone has lost its organic content (Mitchell et al., 2006: 150).

6.3.1 Evidence for weapons/weapon categories

6.3.1.1 Sharp force

Recent studies have recently reported concerns regarding the identification of and potential for distinction between injuries caused by different blades. The identification of specific weapon types is certainly challenging, even where sets of remains are complete and well-preserved. Sharp force injuries are often incompletely represented in skeletal material, for instance fully penetrating cuts may have resulted in the peri-mortem separation and/or loss of the smaller part(s) of the sectioned bone or bones. Even where such injuries do survive in their entirety, the biomechanical properties of fresh bone (i.e. its modulus of elasticity - see Biomechanics) may result in the distortion of the original lesion once the cutting implement is removed: incisions or partial cuts may close up slightly, suggesting a smaller or thinner blade than was actually used to inflict the injury. Conversely, Cerutti and colleagues (2014) reported that almost all the different blade types tested in their study produced cut marks wider than the width of the blade itself and whilst they acknowledged that lesion width increased with blade width, the variation in lesion widths between different blades showed was 'widely overlapping'. The authors concluded that it was not possible at that time to connect lesions with specific blade types due to the variables involved and the lack of knowledge regarding their individual degrees of influence.

The vast majority of the sharp force lesions identified in the Sidon Crusaders are suggestive of heavy-bladed weapons such as swords or possibly axes of some sort. However, there was some potential evidence of differing classes of blade. The articulated left hip and left femur from burial 101 (context 4169_LegG) exhibited a very thin, well-defined linear fracture of the posterior aspect of the femoral head (see Figure 96). There was some slight evidence of associated fracturing of the corresponding superior lateral aspect of the acetabular rim, although this was minimal. It is possible therefore that the wound of this left femur was inflicted with a wider blade than is suggested. However, the injury was estimated to have penetrated the bone to a maximum depth of nine millimetres, yet no evidence of plastic deformation or significant end fractures was observed to the femoral head itself, characteristics that might be expected in such a deeply penetrating wound produced with a broad, heavy blade.

The possibility certainly remains that this wound was inflicted with a smaller, thinner blade more characteristic of a dagger or knife. If this was the case, several potential interpretations for the injury arise. If the wound occurred during battle, it suggests very close-quarter combat with the assailant at no more than arm's length away. Alternatively, the cut might potentially relate to some sort of early post-mortem treatment or processing (yet still within the peri-mortem timeframe of bone mechanical properties); the suggestion being that this cut is very similarly positioned to those observed in dismemberment practices. A third possibility is that this injury represents a form of denigration targeting the groin region, possibly castration, likely occurring once the victim had been incapacitated.

Several of the injuries observed in the Sidon material demonstrate evidence for weapons with extremely sharp blade edges. Most notably one right mandible exhibits complete transection and loss of almost the complete inferior half of the right mandibular body (Figure 97A). Other similarly extreme wounds include the steeply oblique cut down across the proximal third of a one left femur (context 4278_F_L9, Figure 97C), the deeply penetrating cut down through multiple lumbar vertebrae (context 4259, Figure 97B) and the broad deeply penetrating 'scoop' lesion of the superior left side of the head of context 4247, not to mention the suggested bisections of several cervical vertebrae and the possible decapitations they may represent.

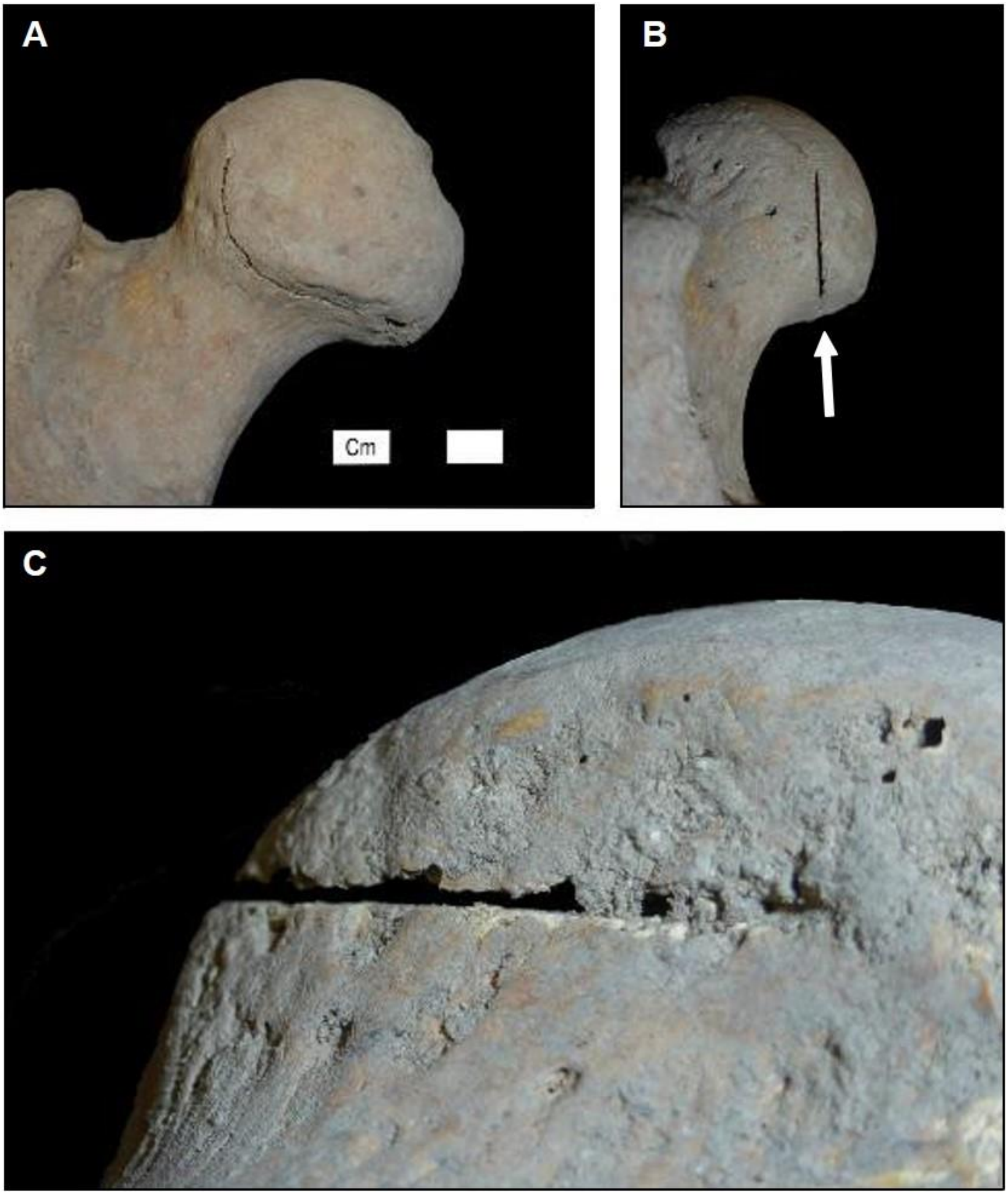

Figure 96: Left femur (B101_4169_LegG), A) Posterior view, showing very thin (<0.5mm) but deeply penetrating linear cut to posterior margin of femoral head; B) lateral view; C) Inferior view showing detail of medial aspect of lesion, with part of soil matrix still embedded within.

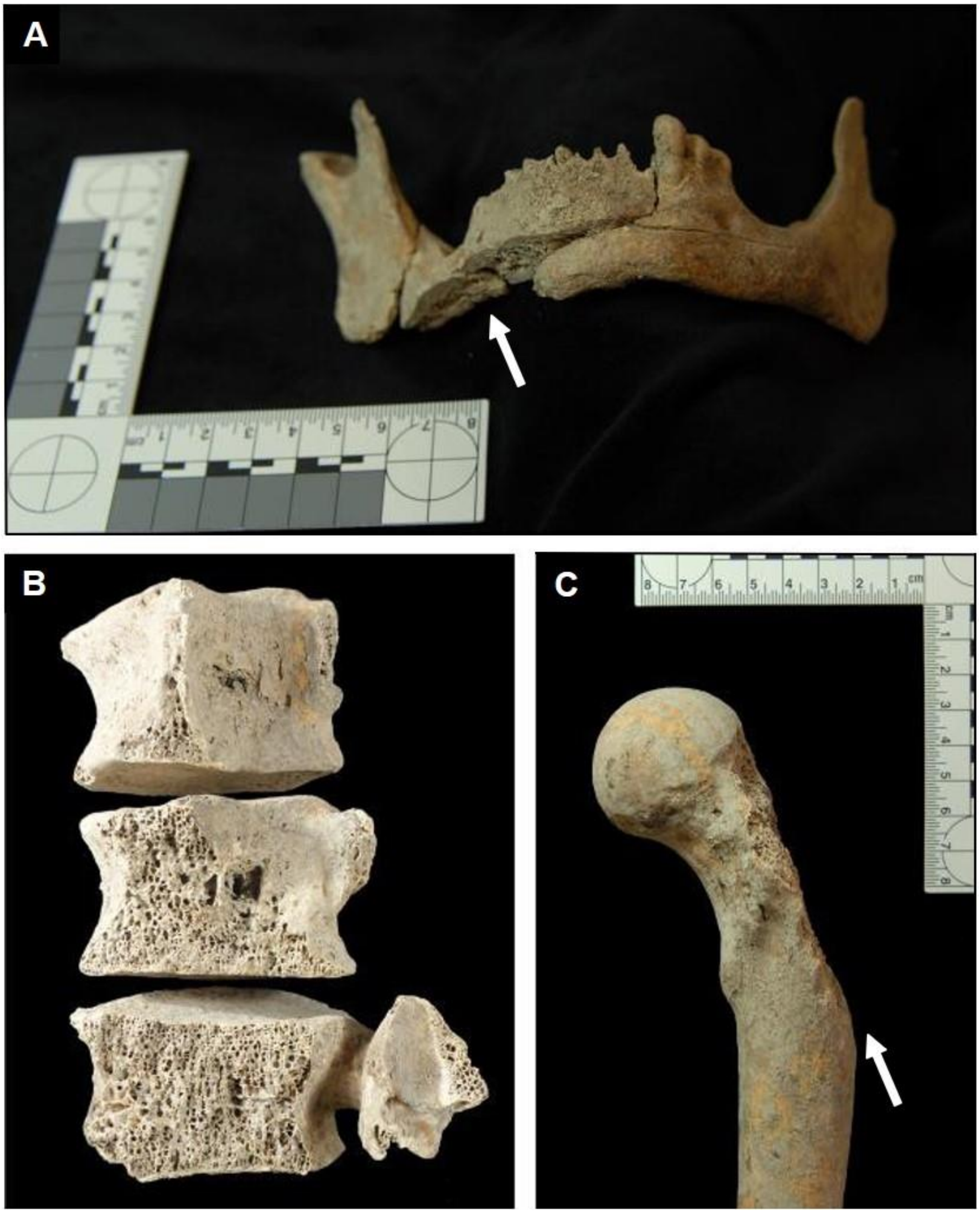

Figure 97: A) Mandible (B110_4203_B_L6-L9), anterior view demonstrating polished cut surface along almost entirely transected right mandibular body, with substantial end fractures of the anterior left mandible, clearly indicative of a peri-mortem transverse heavy sharp cut across the right side of the jaw, with associated blunt force trauma. Left: B110_4311_(4180_QuadD_L2) B) L1/L2-L3/L4 vertebrae (B110_4259_(4203_E_L7)), posterior left view presenting corresponding stained fracture surfaces indicative of peri-mortem sharp force trauma, suggesting a heavy oblique cut across the lower left back. C) Left femur (B110_4278_F_L9), anterior view demonstrating single, long oblique fracture down across lateral aspect of proximal end, with transection/loss of entire greater trochanter, indicative of a heavy peri-mortem sharp force cut to the region of the upper left thigh/left hip.

The contemporary Muslim historian and warrior Usama ibn Munqidh provides an anecdote in relation to his father's sword, which supports the presence of extremely sharp-edged swords in use in the twelfth century. Having been kept waiting by his servant, Usama recounts, his father hit the servant with the sheathed sword in frustration:

> *"The sword cut through the outfit [sword sheath], the silver sandal, a mantle and a woollen shawl which the groom had on, and then cut through the bone of his elbow. The whole forearm fell off."*

(Usama ibn Munqidh, 12th century, in Hitti, 1929: 147)

6.3.1.2 Blunt force

Evidence for peri-mortem blunt force trauma was observed in both cranial and postcranial remains. Bone lesion characteristics found to be most useful in identifying blunt force trauma included plastic deformation and evidence of bone 'tear' or peeling, where the cortical bone shears away, leaving evidence of a spall on the remaining surface. Other useful characteristics included the presence of smooth fracture surfaces, bevelling or oblique/acute angled fracture surfaces relative to endocranial cortical bone surfaces.

Staining of fracture surfaces was generally taken to be a prerequisite for the consideration of peri-mortem timing. This, of course, does not preclude the possibility that breakage occurred post-mortem in antiquity, with fracture surfaces subsequently becoming similarly stained to resemble genuine peri-mortem fractures. Hence, it was felt staining alone could not be used to definitively assess timing of trauma, although it was used to flag possible or probable peri-mortem lesions. This was particularly pertinent to the remains excavated from the lower part (layer 4 down) of the west end of burial 110. The top layers of these remains were first exposed during the 2009 excavation season, but due to time constraints and following clarification that the deposit continued into the unexcavated baulk at the time, it was necessary to recover and backfill the grave until the following season.

Although every effort was taken to protect the remains, using a combination of geotextile and plastic, some evidence of water percolation was suggested when the remains were re-exposed the following year. It is possible that water percolating through the protective covering may have deposited fine sediment on top of the bones, potentially producing staining of any recent dry fracture surfaces which might have occurred either during the first season of excavation or during the interval between excavation seasons.

A further question regarding the use of staining remains. Many of the bone elements or fragments observed to exhibit possible peri-mortem blunt force trauma exhibited differential staining across the fracture surface(s). Although parts of some fracture surfaces were clearly recent, likely occurring during excavation or as the bone dried out, other sections of the same surface could be stained and thus represent at least old dry fractures, if not peri-mortem breaks. It was felt such instances of variable staining across a fracture surface may represent bone fractures that were originally incomplete, i.e. those occurring during the peri-mortem timeframe or at least when the bone retained a portion of its organic content.

It is difficult to be certain whether the majority of the blunt force trauma observed in the Sidon Crusaders can be attributed to interpersonal/inter-group violence, or if the peri-mortem mechanical properties of the bones persisted long enough for these changes to have occurred as a result of taphonomic processes active before, during and after the final deposition of the remains within the fortification ditch. However, the presence and broad distribution of the sharp force trauma observed, along with the circumstantial evidence deriving from both the archaeological context and the historical accounts, would suggest a significant number of the blunt force lesions resulted from the same events that produced the sharp force lesions.

6.3.1.3 The Weapon evidence

Stratigraphically-secure archaeological evidence of either crusader or contemporary Islamic military equipment and weapons is extremely rare (Boas, 1999; Nicolle, 1982; Zouache, 2014-2015: 304); of that which has been excavated, very little has been published (see Raphael and Tepper, 2005; Zouache, 2010).

Crusader period sites which have yielded weapon evidence from archaeological deposits include Arsūf (Raphael and Tepper, 2005; Ashkenazi et al., 2012), Marqab (Török et al., 2017), Montfort (Dean, 1927; Boas and Khamissy, 2016), Sadr (Zouache, 2010) and Vadum Iacob (Mitchell et al., 2006).

With regards to arrows, Raphael and Tepper (2005: 86) suggest that the evidence to date indicates similar types of arrowheads were used by both Frankish and Muslim archers during the 12th and 13th centuries. Of the 1243 arrowheads recovered during archaeological excavations carried out at Arsūf, almost all are of a similar type with the average length 4.5cm, the width being approximately 1cm. The cross section was either square or diamond-shaped, demonstrating they were primarily armour- piercing in design (Raphael and Tepper, 2005: 85-86). Figure 98 shows the types of arrowhead reported at Arsūf:

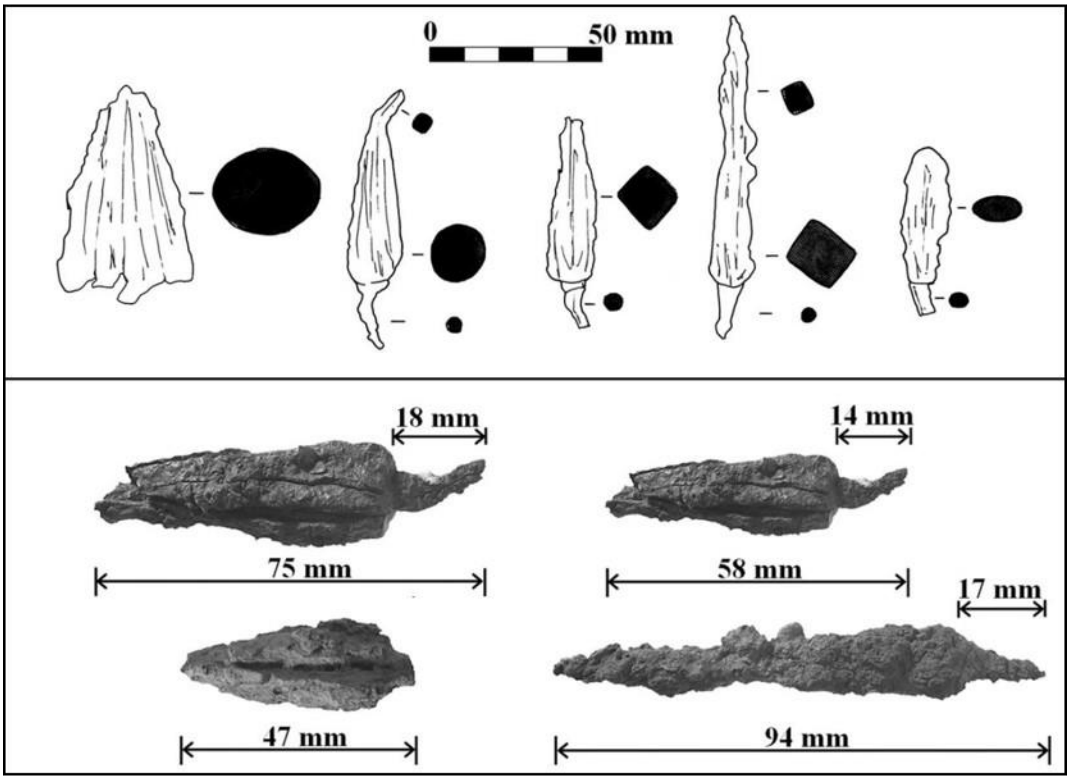

Figure 98: Typical iron arrowheads recorded at Arsūf/Arsur. Note all examples are tanged rather than socketed in contrast to the copper alloy arrowhead recovered from burial 110 at Sidon (Amended after Ashkenazi et al., 2013: 238, figures 2 and 3).

Only five arrowheads differed from this design and these were all kite-shaped and flat, a design generally suggested to have been preferentially used in hunting wild game or, alternatively, for wounding horses and mounts in battle.

It is striking that at Sidon there is a distinct lack of evidence for arrows. It is possible that taphonomic conditions have not allowed for the good preservation of such small, iron objects. Even so, the preservation of iron artefacts within burial 110, in particular the iron nails and the very small iron tacks, argues against this explanation.

Swords and sabres

During the earlier part of the ‘Abbāsid period, Ibn Akhī Ḥizām advocated the use of a shorter sword by cavalry as it provided easier handling in the saddle and well-made examples were more effective for cutting than long swords which he believed were more suited to infantry (Ibn Akhī Ḥizām, fol. 69a in Al-Sarraf, 2002: 172). Al-Sarraf (2002) provides measurements for the types of swords in use during the Mamlūk period. Citing al-Kindī, Al -Sarraf describes the most common blade length of sword during the ‘Abbāsid period was approximately 90cm, representing a medium-short sword, with the shortest example measuring roughly 76cm and the longest 112cm. Al-Sarraf implies sword lengths had increased by the time of the Mamlūks, with typical *qaljūrī* double-edged swords exhibiting blade lengths varying from 80 – 90cm, although exceptions occur with one example in the Topkapı Museum having a blade of 123cm (Al-Sarraf, 2002: 173). The term *qaljūrī* and its equivalents became common in the Arabic literature from the 11th century onwards, although the earliest references to such swords derive from Fāṭimid sources in Egypt. These swords were described by contemporary sources as having curved blades (Al-Sarraf, 2002: 171). Despite the development of such early examples of the sabre, Al-Sarraf stresses that straight, double-edged swords also remained “*… an omnipresent aspect of the military arsenal throughout the Mamlūk period.*” but concludes the *qaljūrī* curved form was more widely used by the Mamlūks, who valued its functional aspects which allowed both effective cutting and thrusting actions (Al-Sarraf, 2002: 170).

The illuminated manuscript of William of Saint-Pathus contains a miniature depicting the fighting at the battle of Mansourah, with at least two of the Crusaders’ opponents wielding distinctive curved and pointed swords (Figure 99). Although this image is considerably later than the events of the Seventh Crusade, the presence of such curved swords fits well with the pattern and timing of their development.

Figure 99: The Battle of Al Mansourah (1250), as depicted in Guillaume de Saint-Pathus' Vie et miracles de saint Louis, c. 1330-1340. Bibliothèque nationale de France, Ms. Fr.5716, f.199. Original image: Gallica Digital Library/BnF.

Sabres later became increasingly prevalent as cavalry weapons, even after the introduction of early fire-arms into the Early Modern period. One individual from the Gołańcz castle mass grave (attributed to the 1656 siege and subsequent massacre on the site) presents a sharp force injury of the left temporal bone, with the majority of the mastoid process transected and missing (Łukasik et al., 2018: 8, fig. 4c), for which there is an almost identical cut to a right temporal from burial 110 (context 4301). This lends some support to the interpretation of mounted troops using curved, sabre-like swords. Counter to this, however, is another example of a very similar wound reported at the Viking period execution site at Ridgeway Hill (Skull 3728 in Loe et al., 2014: 78, fig. 3.34), although interestingly the authors also interpreted the assailants to have been elevated relative to their victims.

Axes

Common Arabic terms for axes in the Muslim Near East include *fas*, *ṭabarzīn* and *ṭabar*, but only the latter two terms were used to indicate a war-axe. Two general categories of axe are broadly accepted as forming part of the Islamic military arsenal from the early medieval period onwards. The first of these constitutes a smaller type, usually considered to be a saddle-axe, consisting of a light, short hafted, small-bladed war-axe used by cavalry. The second category is characterised by much larger examples, with long-hafts, representing heavy-bladed war axes (Al-Sarraf, 2002: 162). However, Al-Sarraf (2002) argues that the dual nomenclature derives from different chronological periods rather than indicating the two separate types of war-axe.

Never-the-less, there is evidence for both types of war-axe within the historical accounts. As already noted in Weapons, the Islamic troops are described as carrying 'Danish' axes in the mid-13th century, although no details are provided as to the specific group wielding them. The contemporary Rothelin Continuation text describes the rout following the Count of Artois' disastrous attack on the town of Mansourah and the Crusaders' subsequent chaotic retreat from the town:

> *"Some fled towards the river to escape death, but the Saracens were on their heels, bringing them down with Danish axes, with maces and swords, …"*

(Rothelin Continuation, Ch. 64 (1250) in Shirley, 1999: 96)

Joinville provides more detail in his first-hand account of the events in the immediate aftermath of the battle and the Crusaders' defeat. He recounts how, during the Mamlūk coup d'etat and whilst he was captive on board a galley, a group of Mamluks came aboard with drawn swords and "*… Danish axes hanging at their necks.*" (Joinville, [§354], in Smith, 2008: 233). In the following section, Joinville describes one of these individual's weapons as a "*… carpenter's Danish axe.*" Together, Joinville's observations suggest these Mamlūks carried the smaller type of axe, with a short haft that was more portable and certainly more practical to those trained to fight on horseback. This is corroborated to some degree within the Arabic *furūsiyya* literature, with sources describing horsemen's axes as having either quite large, bearded (see **Error! Reference source not found.**) or c rescent-shaped blades and in at least one reference, a rather short haft (Al-Sarraf, 2002: 164). Al-Sarraf does, however, argue that by the Mamlūk period, the war-axe or ṭabar had become a high-status weapon, with its use limited to high-ranking officers (Al- Sarraf, 2002: 164). Figure 100 below shows the similarity between what is considered a northwest European bearded axe-head, broadly contemporary with the crusades, and a later period Mamlūk war-axe.

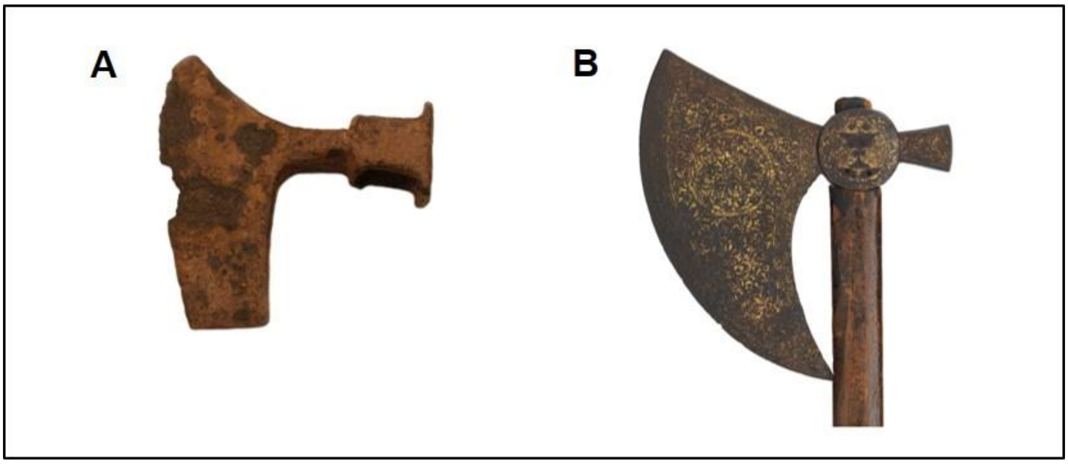

Figure 100: A) Head of a bearded battle-axe, perhaps northwest-European, 1100-1350 (19.7 x 18.4cm, 2lb). Worcester Art Museum, The John Woodman Higgins Armory Collection, 2014.675. Original image: Worcester Art Museum; B) Battle-axe with Mamlūk blazon, inlaid with gold, Syrian, c. 1450-1500. (Height of axhead 10¼ in. (26.0cm), 2lbs 14oz). Metropolitan Museum of Art, New York, Purchase - Bashford Dean Bequest, 69.156. Original image: Metropolitan Museum of Art, New York.

Certainly, both swords and axes, whether long-hafted or short-hafted, were clearly capable of inflicting the types of weapons. Some of the extreme injuries identified and those others of injuries evidenced in the human remains from the crusader mass grave deposits. However, the incomplete and highly fragmented nature of the skeletal material inhibits the identification of wounds specifically attributable to one or other group suggested, indicate either very heavy strikes or extremely sharp implements or more likely a combination of the two.

Maces

Concerning the use of blunt force weapons, the series of superficial lesions observed to the superior left side of the back of the head of context 4247 can potentially be interpreted as subtle evidence of a heavy, multi-pointed object impacting the cranium, perhaps at the anterior-most lesion where there are slight radiating fractures, and rolling in an arc posteriorly across the surface of the head (see Figure 68). Ingelmark (1939: 191), in his early treatment of the human skeletal remains from the Battle of Wisby, stated that mace injuries were extremely difficult to identify due to the nature of the trauma they produced.

More contentiously, he proposed such crushing of long bones or the cranium generally resulting from mace impacts could not be distinguished from post-mortem crushing occurring within a mass grave due to settling, although he does not specify whether he is comparing peri-mortem trauma with ‘wet’ or ‘dry’ post-mortem fracturing, the latter of which would generally be discernible from peri-mortem blunt force fractures. Distinguishing any blunt force trauma resulting from actual battle, not just mace injuries, from post-depositional breakage occurring while bone retains collagen (i.e. remains ‘wet’) is never-the-less problematic.

Even so, at Sidon, one may argue that the relatively small size of the mass grave pit (burial 110), and the consequent limited amount of material able to be contained within it, might well have mitigated against the effects of post-mortem breakage of ‘wet’ bone occurring within the grave due to settling and overburden. In addition, and with specific reference to mace injuries, Ingelmark was possibly too pessimistic, as he seems to have neglected the possibility of identifying the potential lesions caused by either spiked or flanged maces. Spiked maces are certainly attested in the archaeological record for the crusader period. A relatively well-preserved example was excavated at the site of Vadum Iacob, dating to the late 12th century (see Figure 15E). Thus, although far from being a definite case given their ephemeral/ambiguous nature, the cranial lesions observed in context 4247 certainly give pause for thought that such injuries are potentially identifiable.

Some of the cranial and postcranial peri-mortem trauma presents as partially shaped or angled depressions that are highly suggestive of low velocity direct trauma caused by shaped or angular heavy blunt objects. The association of the sharp force wounds within the group makes it clear that these peri-mortem lesions are most likely the result of the same violent encounter. In this context, these lesions may well have resulted from direct impacts from a variety of different blunt weapons such as war- hammers, clubs, maces, the hilts of swords, the hafts of axes or spears. Alternatively, some of these injuries, particularly where indirect trauma is indicated, may have been the result of other impacts likely occurring during inter-group violence. In the midst of battle, it is not hard to imagine being knocked down either by an opponent on foot or any mounted rider.

Al-Sarraf (2002: 152-161) traces the development of mace weapons in the Muslim cavalry from the ‘Abbāsid period until the Mamlūk Sultanate. In the early Islamic period, he describes how such weapons were broadly categorised into two distinct classes, the high status *amūd* (a solid steel or iron mace or short staff) and the relatively low-tech *dabbūs* (a lighter, round- or oval-headed mace, with a wooden shaft). According to Al-Sarraf (2002: 159), the historical literature indicates the second of these weapons was closely associated with the ghīlman troops, the initial institution of slave warriors established under al-Mutaṣim, a tradition later carried on with the founding of the Mamlūk military institution. The heads of these lighter maces varied and included round-, oval- and cucumber-types (the last indicating a cylindrical form). By the time of the Mamlūks, the two main categories of maces appear to have been joined by a third intermediate weapon – the *latt*. This was a heavier mace than the *dabbūs,* potentially with a head of elongated teeth mounted on either an iron or wooden shaft, with a specific grip of shagreen. The reduced cost and easier handling of this heavier form of *dabbūs* appears to have rendered the *amūd* obsolete by the end of the 10th century. By the First Crusade, the terms *dabbūs* and *latt* were almost interchangeable, but the former predominates from the 12th century onwards, having become a generic term for studded maces. The order of Sayf al-Dīn Ghāzī ibn Atābik Imād al-Dīn Zankī of Mosul (d.544/1149) for his troops to carry a *dabbūs* attached to their saddle at all times supports the ubiquity of this weapon during the first half of the crusader period at least (Al-Sarraf, 2002: 161).

Certainly, it seems the *dabbūs* or one of its various forms may well have inflicted some of the blunt trauma evidenced in the skeletal material from burials 101 and 110. However, depending on the context and the assailants involved (i.e. either Mongols or Mamlūks, or possibly one or more other contingents of the Muslim army) one cannot exclude other heavy weapons, such as the Iranian bronze war hammers and mace head depicted in Figure 15A-C).

6.3.2 Peri-mortem trauma patterning

6.3.2.1 Overall distribution

Grouping all the human remains from burials 101 and 110 together, the overall distribution of the definite peri-mortem trauma does not reflect a single, clear and consistent pattern across the body. It does, however, reflect probable evidence of several modes of fighting.

The distinctive concentration of blade wounds of the cervical region suggests deliberate targeting of this region. These cuts present some variety, particularly in their transverse angulation across the neck, as well as their depth of penetration but also demonstrate a general patterning indicating targeting of the back of the neck, with a slight focus on the right side suggested. In some contexts, this could be taken to suggest evidence of formal execution. Yet, the presence of other peri-mortem trauma distributed across the body and more significantly the variety in the penetration, siding and angulation of the cervical cuts themselves argue for a less ritualised situation dictating their occurrence. Certainly, a randomised pattern of trauma is considered incompatible with interpretations involving formal execution (Jordana et al., 2009: 1325; Lovell, 1997).

On the other hand, one would not anticipate the back of the neck to be an easy target when fighting on foot, whether face-to-face with an adversary or chasing down a retreating/routed opponent. We might anticipate defensive wounds to the hands and upper limbs and targeting of the head or anterior left side of the neck in the case of the former and injuries to the back, legs (tibiae and fibulae) and feet might be expected to be more prevalent in the latter situation.

On the whole the prevalence of cuts across the posterior and posterior right aspects of the neck suggests one or more assailants striking from an elevated position such as would be the case if the actor(s) were mounted on horseback. These wounds, along with several others (including both sharp force cuts to the cranium of 4247 and the cut down across the tip of the right acromion of the same individual), are clearly consistent with a right-handed attacker on horseback, riding past an opponent on foot on the latter's left side, targeting the back of the neck with a heavy sharp-bladed weapon such as a sabre.

There is clear evidence of peri-mortem defensive wounds, with at least one individual exhibiting a heavy sharp force cut to the back of the right hand, indicating this individual at least was free to attempt to protect/defend themselves (Larsen, 1997). Several authors have previously proposed that random distributions of skeletal trauma across the body may be indicative of conflicts involving defence of communal property, ambush or surprise attacks but do not result from 'routinized or ritualised violence' (Larsen, 1997; Milner, 1999; Paine et al., 2007; Steadman, 2008; Tung, 2007). Jordana et al. (2009: 1325) state that attacks in the former categories do not appear to involve selected groups and can include individuals of all ages and both sexes. In contrast, 'ritualised or routinized' violence might be inferred from a rigid, well-defined patterning of peri-mortem trauma such as decapitation of multiple individuals as observed at Ridgeway Hill, Weymouth, interpreted as an informal execution event (Loe et al., 2014).

6.3.2.2 *Other interpretations of fracture/cut types*

Lighter cuts or incisions have been interpreted as being indicative of ritualised violence such as scalping or trophy-taking (Jordana et al., 2009: 1326). Such practices have been reported amongst numerous cultures widely distributed both temporally and spatially (Lambert, 2002; Steadman, 2008). Jordana et al. (2009: 1326) use the co-presence of both fatal injuries and lighter cut marks to support an interpretation of scalping in the aftermath of conflict, making reference also to an early historical/broadly contemporary account of such practices attributed to the Scythian culture in this region at the time.

Given the presence of multiple confirmed peri-mortem traumata in multiple individuals, it is highly probable the peri-mortem injuries observed are an under-representation of the true number and variety of trauma suffered by the individuals from burials 101 and 110. Soft tissue injuries, ranging in severity from superficial cuts and bruises to wounds of a fatal nature, can be sustained without impacting the skeleton. Such wounds would obviously be unobservable on the skeleton (Gurdjian et al., 1950; Knüsel, 2005). It is worth noting here that context 4247 (Section 5.3Case Study 1: Context 4247), exhibited significant trauma, particularly to the cervical region, representing at least six blows to the neck, suggesting an excessive assault on the individual even after he was incapacitated.

Considering the trauma patterning, both as a single group and in specific individuals, some potential inferences concerning identity may be posited. In some instances, historical sources contemporary with the Crusades indicate some individuals were less likely to be shown mercy or taken prisoner than others. For example, during the battle of Mansourah in 1250, the Muslim troops were particularly ruthless concerning the enemy's crossbowmen, and we are told all those taken prisoner were *"…killed without mercy…"* (Rothelin Continuation, Ch. 64, in Shirley, 1999: 97). Unsurprisingly, political and popular aggression also appears to have varied diachronically. During the early Mamlūk period, which overlapped with the last quarter of the Frankish States, Islamic *jihad* once again came to the fore. Hillenbrand (1999: 242) suggests that this renewed sense of holy war was appropriated and encouraged by the foundling Mamlūk empire, politically expedient as it was in order to unify the Muslim nations under their rule, particularly in the face of the new Mongol threat from the east as well as against the irritable Franks who remained and the possibility of their support from the west. She states that the Mamlūks presided over a period of increased fanaticism within Islam and that the goals of their military leaders sat neatly with the ideals and teachings of religious leaders at this time.

At Sidon, context 4247 (see Section 5.3) stands out as having suffered an excessive amount of trauma, representing multiple blows, probably inflicted with a variety of weapons. This individual has also been characterised as being of recent European ancestry, contrasting with the majority of the Crusaders sampled for aDNA analyses (Haber et al., 2019). The only other substantially articulated set of remains from the mass graves, context 4147 (Section 5.4), was also sampled for aDNA as well as for strontium and oxygen isotope analysis. Although peri-mortem trauma was identified on these latter remains with cervical sharp force trauma again in evidence, the individual appeared to have suffered considerably fewer violent skeletal injuries than 4247. The results of the aDNA analysis for 4147 have suggested a local, Lebanese ancestry and this is supported by the isotopic evidence (see Section 5.7.1) which places the individual closer to the suggested signal range for local residents, indicating this individual had grown up in the Near East. Is it then possible that the excessive trauma to which 4247 was subjected, was a result of their Western European origins which may have incited a greater degree of battle rage from their attacker(s) in this time of renewed religious fervour? It may simply be that this individual was larger or stronger (i.e. posed more of a threat) and/or put up more resistance, thereby becoming a priority target, although this is not incompatible with the interpretation of specific prejudice or pure blood frenzy.

Taken together, the human skeletal remains from burials 101 and 110 at College Site, Sidon exhibit a broad variety of peri-mortem traumata distributed across the whole of the body. Although some similarities are observed, the results from the Sidon mass grave deposits appear to contrast significantly with the data published for the Ridgeway Hill Viking period execution site (Loe et al., 2014). At both Sidon and Ridgeway Hill, there is significant evidence of a sharp force focus on the neck, yet the latter site exhibits an almost total absence of peri-mortem trauma below the level of the shoulders, other than the hands (the exception being a single cut to the iliac crest of a right ilium). Whilst more comparable with the trauma reported for the individuals from a mass grave associated with the battle of Towton (Novak, 2007: 92), the Sidon Crusaders still appear to differ somewhat, exhibiting considerably more evidence of peri-mortem postcranial trauma. However, the lack of peri-mortem trauma of the torso (i.e. the ribs) is consistent with Novak's observations at Towton, where the author reported no peri-mortem rib trauma to either the chest or the back (Novak, 2007: 93). Yet, as Novak notes, in a group of burials from Fishergate, in York, dating to a slightly earlier period (11th and 12th centuries), peri-mortem cuts were observed in 19 out of 29 individuals exhibiting peri-mortem sharp force trauma (Stroud and Kemp, 1993). Although there is one clear exception at least (see Figure 97B), this apparent lack of peri-mortem thoracic trauma may potentially indicate the use of body armour or protective clothing, with the result that other, more vulnerable parts of the body were targeted.

At Towton, Novak (2007: 93) observed the right upper limb to be the dominant upper limb, with the majority of postcranial injuries occurring in this appendage. She points out that the presence of defence injuries does not preclude the possibility of these individuals having wielded weapons, and argues that for right-handed individuals, the right upper limb and hand would have been the lead in delivering blows and consequently this upper limb would be more vulnerable to injury during an opponent's counter-attack. Similarly, a weapon, used to parry or defend offensive blows would likely have been held in the right hand, thus again rendering the right upper limb vulnerable to injury. Obviously, this danger would be exponentially greater if the individual held neither weapon nor shield to parry with or otherwise protect themselves; in which case either hand might be used to defend likely depending on a combination of factors including individual handedness, the individual's position/posture and the direction from which the blow was coming. Novak's suggested interpretations marry well with at least one of the injuries observed within the Sidon Crusaders. One right upper limb exhibited evidence of multiple sharp force cuts including a heavy blade strike that partially penetrated the back of the right wrist.

6.3.2.3 Extreme injuries

Some injuries evidenced in the skeletal material from burials 101 and 110 indicate major trauma, possibly resulting from single, extreme blows. In particular, the three cut lumbar vertebrae of context 4259 (Figure 97B) represent a powerful blade strike to the lower back of the individual which would have had to penetrate a substantial amount of muscle and soft tissue, before transecting the vertebral bodies, not to mention any clothing or armour the individual was wearing at the time.

Certainly, from the crusader perspective such wounds appear to have been possible, sometimes with specific weapons indicated. The Maciejowski bible depicts a particularly gruesome injury to the lower back of one unfortunate mounted individual, inflicted with what appears to be a short-handled glaive, which his assailant wields double-handed whilst also on horseback (see Figure 101). This wound bears remarkable similarity to the orientation and severity of the sharp force cut affecting three lumbar vertebrae in one individual from burial 110 at Sidon. It seems quite feasible that Muslim weaponry of the time, which does not appear to have differed greatly from that of the Franks, would have been capable of similar injuries. Indeed, it could be argued that the general preference of Muslim army for mounted warfare would have resulted in large numbers of such injuries where they committed to close-quarter engagements. There are hints of other such injuries from the mass grave deposits, perhaps the most striking of which is the isolated anterior cranium and cranioviscera of context 4234. These articulated/closely associated remains together represented the majority of the individual's face including frontal bone, both left and right zygomatic bones, the majority of the maxilla, nasals and the mandible (see Figure 102).

Figure 101: Detail from the Maciejowski Bible, demonstrating wound with similar positioning to that evidenced in Figure 97B. Pierpont Morgan Library. Ms M.638 f.10v. Original image: Pierpont Morgan Library. Available [online] at: https://www.themorgan.org/collection/crusader-bible/20 (accessed: 13/08/2019).

Figure 102: Burial 110, Detail of mid-excavation photograph, showing articulated cranioviscera of context 4234 in situ. Note the cranial remains directly overlie the distal end of a femoral shaft as well as a group of vertebrae. Image: R. Mikulski.

During excavation it was initially thought perhaps that the cranium had been deposited face up, with the remainder of the posterior cranium lying deeper within the burial deposit. However, it subsequently became clear that the articulated facial bones directly overlay a femoral shaft, with no indication of disarticulated parietal bones. Indeed, no other cranial remains were observed in direct association. The possibility that the remains of the face had become disarticulated following the loosening of the coronal suture and basioccipital region was briefly considered, but it was clear that some small fragments of the anterior parietals remained attached with at least part of the coronal suture intact. The articulation of these facial bones and their complete separation from the rest of the cranium certainly implies they had been separated prior to deposition and while soft tissue remained, which had no doubt kept the delicate remains of the cranioviscera relatively protected and maintained the integrity of the facial region.

In the case of context 4234, therefore, it is not difficult to imagine the type of catastrophic head injury which may have resulted in the separation of the anterior cranium and face from the rest of the head. Finds of such isolated parts of the body, not normally found disarticulated in such a manner, suggest the extreme battle injuries represented in the archaeological/iconographic records and described within historical accounts were quite possible amidst the reality of late medieval warfare. Furthermore, in both cases of the mid-late 13th century depictions illustrated in Figure 103A-B below (see also Nicolle, 1988, vol. II: 832, figs. 957C-D and 830, figs. 953A-B), the extreme blows are being delivered by assailants on horseback, suggesting perhaps that such wounds were most often a result or even only achievable with the added momentum a mounted attacker had at their disposal.

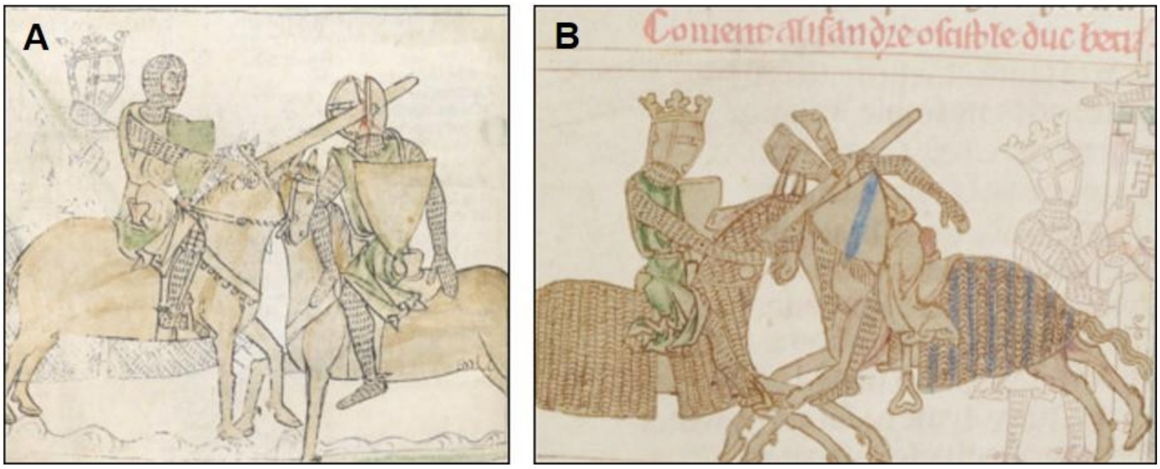

Figure 103: Extreme injuries depicted in the crusader period iconography - A) Detail of miniature from the *Chanson d'Aspremont*, England, c1240 - c1250. Modified after original image © British Library Board, Ms. Lansdowne 782, f.12v; B) Detail of miniature from Thomas of Kent's *Romance of Alexander*, England, 13th century. Trinity College Cambridge, Ms. O.9.34, f.007v. Modified after original image: Master and Fellows of Trinity College Cambridge; see also Figure 101.

It is also worth noting that the retention of small, transected fragments and their recovery in situ indicate that remains did not remain unburied for long enough for advanced soft tissue decomposition to take place and for the cut bone pieces to be lost. If such small fragments of bone were retained with the body, this raises the question of why significantly larger portions of the body were not also present and in relative articulation. Therefore indirectly, this suggests evidence of other heavy wounds or, alternatively, that individual bodies were significantly differentially preserved (with some regions of the body perhaps having been less exposed than others) despite an extended interval between death and deposition within the grave pit. Considering the evidence of the multiple peri-mortem traumata already described, it is suggested the former may be more likely but certainly differential preservation should be considered, especially within an urban environment, where taphonomic variables such as sunlight exposure, animal scavenging and access to remains are likely to have varied markedly.

Given the extended time period of the Frankish states and the gain and loss of Sidon several times over the course of the Crusader period, there are clearly multiple different contexts in which the inhabitants of Sidon or groups passing by may have been subject to a variety of assaults. Residents both within the city and living in the countryside surrounding Sidon would have been subject to both short and long-term sieges and opportunistic raids perpetrated by large armies often incorporating a wide variety of troops with different weapons and tactics as well as varying levels of skill and experience in fighting and siege-craft.

Taking the group as a single entity, the broad distribution of wounds across the entire body would appear to indicate a battle or raid situation involving at least some hand-to-hand fighting. This is supported at the individual level by the incomplete remains of context 4247 which exhibit a minimum of thirteen separate injuries, representing both sharp and blunt force trauma and involving both cranial and postcranial elements. Furthermore, the presence of probable defence injuries amongst the group, lends additional support to the interpretation of the victims having had free movement and the opportunity to defend against some blows (i.e. they were not bound prisoners).

The higher number of confirmed injuries to the head, neck, shoulders and upper torso is consistent with assailants striking from an elevated position such as would be the case if attackers were mounted on horseback. Furthermore, the high number of injuries directed from behind would also be consistent with a situation in which individuals on foot would have been at a disadvantage to mounted opponents and potentially retreating from their assailants.

Novak (2007: 101) has previously noted the variation in the wound-patterning observed in other late medieval graves such as those from the Battle of Wisby (1361), where the majority of sharp-force cuts observed were to the tibiae (Ingelmark, 1939). She goes on to warn that variation within individual conflicts should be considered if not expected. With this in mind, despite the apparent prevalence of injuries of the head and upper body, the presence of significant peri-mortem wounds of the knees provides potential evidence of opponents fighting on foot.

The analysis suggests the pattern of injuries observed within this group of remains is consistent with hand-to-hand fighting in an intense battle situation with opponents in close proximity to each other. There is evidence of some assailants using highly efficient weapons of war (e.g. some clearly had extremely sharp-edged blades) and strong evidence of at least two classes of blade used to inflict injuries on the victims. Some injuries appear to have followed on from incapacitating wounds, with attackers potentially finishing off individuals (or putting them out of their misery?) as with the multiple cervical cuts to several individuals, in particular, the excessive, multiple, deep cuts to the neck of one individual. This last example can also be interpreted as mutilation of the individual, whether a result of 'battle frenzy' or a deliberate and concerted attempt at decapitation. One other peri-mortem lesion also suggests the possibility of mutilation, this time to the region of the groin.

6.3.3 Antemortem trauma

Only a single confirmed well-healed antemortem long bone fracture was identified amongst the skeletal material. This was observed in a long bone section made up of several fitted burned fragments (recovered from context 4203_F_L4), and most likely represented an unsided radius (see Figure 106A-B). This fracture had not been reduced within the healing time frame and exhibited complete overlap, with no apposition evident, as well as marked angulation. There was also evidence of a cloaca, suggesting the possibility that the individual had suffered infection secondary to the fracture.

This evidence of such a lack of treatment, particularly the lack of reduction, is in stark contrast to the historical records, which record the practice of bone-setting and fracture treatment as of paramount importance within the Frankish states, with associated medical licensing standard practice by the 1240s (Mitchell, 2004b 231). The indication that the individual received such poor treatment or none at all suggests several interpretations: a) the injury occurred prior to the introduction of medical licensing and regulation; b) that the individual suffered the injury outside of the Crusader states or otherwise in a location where medical treatment was not an option; or c) that medical treatment was not, in fact, widely available but rather that the laws governing good practice were designed to ensure the correct treatment and health of only its leading figures and most important military elements.

The presence of at least four individuals exhibiting evidence of well-healed trauma to the anterior or superior cranium indicates the presence of recidivists, given their context in the mass grave. At the very least, this suggests these individuals had each been involved in a minimum of one previous physically traumatic event. Two, possibly three, of the wounds potentially represent well-healed sharp force injuries indicating these previous encounters involved interpersonal if not inter-group violence. The Crusader states, and Europe and the Levant in general, are well known to have been subject to almost regular warfare and violence throughout the medieval period. Consequently, it is easy to envisage that these individuals may have been professional soldiers or at the very least had former experience of violent environments.

6.4 Aftermath: Taphonomic Conditions and Funerary Context

6.4.1 The Taphonomic context

It is important to consider the evidence of the taphonomic conditions and processes likely to have affected the human skeletal remains from burials 101 and 110. Understanding how the socio-cultural (as represented in funerary practices) and environmental factors influenced the preservation of the remains, directly impacts our capacity to interpret them correctly. For instance, within the archaeological context, the identification of cut marks and their subsequent interpretations came under scrutiny early on, with limitations highlighted following the acknowledgement of the potential complexities of the context in which they were discovered (e.g. Lewin (1984) emphasises the possible taphonomic variables potentially involved referring to James Oliver's work at the Shield Trap cave site in Montana (Oliver, 1989)). Similar issues have been highlighted in the forensic arena with a case of a rib lesion initially thought to represent peri-mortem sharp force injury but subsequently assessed formally as resulting from animal activity) (Symes et al., 2012: 365, fig. 17.5). Taphonomic processes can also "*mimic blunt force injuries or remove important indicators of peri-mortem trauma*" (Moraitis and Spiliopoulou, 2006: 227). Thus, in interpreting the context of the mass graves, it is essential to consider the issue of equifinality. Through a detailed evaluation of the taphonomic sequence of the remains, alongside evidence of the site formation processes, we may thereby arrive at a reliable interpretation of the remains, their social context and the physical events that produce them.

Burials 101 and 110 clearly represent a concerted effort to group remains together within the fortification ditch, outside the Medieval town at Sidon. This accumulation could have taken place in several ways. The process could potentially have been carried out rapidly within a limited time, either close to the time of death or long after. Alternatively, the remains may have been collected slowly over an extended period, potentially lasting months or even years.

A year after the battle at the Horns of Hattin in 1187, Ibn Al-Athīr reports that the battlefield was covered with bones:

> *"… which could be seen even from a distance, lying in heaps or scattered around. These were what was left after all the rest had been carried away by storms or by the wild beasts of these hills and valleys."*

(Al-Athīr, XI, 351-5 in Gabrieli, 1984: 124)

However, the context of the mass grave deposits at Sidon represents an entirely different setting, integrated as they are within the very fabric of the medieval urban landscape. It seems unlikely and unwise that such a situation as described by Ibn Al-Athīr should be permitted amid a significant medieval port-town. Even if such was the case and burials 101 and 110, (taken either together or separately) represented an accumulated assemblage(/s) with remains belonging to individuals who died in multiple, separate events over an extended period of time, then significant variation in preservation states of different elements or groups of elements might be expected to be observed, especially if the deposits accumulated over a longer period of months or years. Clearly, then, one might expect significant differentiation in the taphonomic preservation of the remains in the two deposits. Yet, in general, the preservation state of the remains was good and relatively consistent, (ignoring for the moment, the effects of thermal alteration, generally interpreted as having occurred within burial 110). Both burials consisted of multiple, incomplete individuals represented by both disarticulated and partially articulated skeletal remains, with similar evidence of multiple trauma to several individuals in each deposit. The argument that the remains from both mass grave deposits represent a single event is further strengthened by the presence of at least two matched fragments between burials 101 and 110, clearly indicating that the remains of at least one individual are represented in both deposits. The similar taphonomic condition and appearance of these fragments suggests they were deposited at the same/a very similar time.

Even considering the two deposits as a single event occurring relatively close to the time of death, it is quite possible other human and animal remains, not directly related to the violent conflict were also mixed in with burials 101 and 110. The isolated cranium close to the inner edge of the ditch (context 10153) no doubt dates to an earlier period of the Crusader states; and at certain intervals, it would not be surprising for there to have been other isolated bones or small groups of remains lying discarded and exposed within the ditch or indeed further afield. For those collecting the remains together to form the two burial deposits, it may have been difficult to distinguish between older remains and those of the recent victims, especially if preservation varied considerably, if indeed any effort was made to do so. Despite the possibility of some stray inclusions of unrelated material, there is little doubt that the two deposits represent a single, deliberate attempt to collect together a large number of human remains which demonstrated considerable articulation at the time of their deposition, with the reasonable interpretation that these individuals had died only a short period of time before.

Concerning this post-mortem interval between the individuals' deaths and their deposition, a question persists concerning the possibility that the bodies were more complete or even fully articulated at the time of burial. Tuller and Hofmeister (2014: 20, fig. 2-5) report a median distance of 0.29 m between disassociated bodies/body parts within a large, modern, complex secondary mass grave, with distance varying from less than 10 cm to over 7.5 m. The small median distance might be used to suggest that, once buried, bone elements do not travel far from associated remains as a result of settling within a large-scale mass grave. Within a smaller grave then, one might logically expect smaller distances between individuals' dissociated remains or body parts due to settling, with the conclusion that, had the skeletal remains been largely articulated when deposited, clear associations would have been observable during excavation. Thus, when considering burials 101 and 110 at Sidon, the complete disassociation of a sacral fragment, (later re-associated using articular morphology), from the auricular surface of its corresponding *Os coxae*, and their incorporation into distinct deposits separated by more than 0.5 m could be inferred as strong evidence against their natural disarticulation. Even so, the variation in the type and density of the fill (e.g. the lenses of burnt/cremated material and the presence of voids) means the possibility that settling of the remains and subsequent in situ dissociation of originally articulated elements (especially the smaller bones of the hands and feet) within the pit cannot be completely discounted.

The majority of remains exhibited a relatively good state of preservation, with cortical surfaces largely unweathered. Some isolated elements did present variable cortical preservation including some cranial material as well as postcranial elements (see Figure 104). In one case, this taphonomic deterioration of the cortical bone surface was used to indicate matching fragments, facilitating re-fitting of the two broken ends of a left femur recovered from either end of the pit of burial 110.

Figure 104: Left femur (B110_4311_(4180_QuadD_L2)), anterior view, showing eroded bone surface and differential staining, interpreted as the result of weathering and sun-bleaching. Note one, possibly two longitudinally aligned parallel grooves or incisions (white arrow) – Possible evidence of scavenging or alternatively single deep incision may represent possible weathered sharp force lesion.

This allows an insight into the timing of the weathering which clearly took place prior to the post-mortem fracturing, separation and deposition of the two fragments. This provides support for the interpretation that the remains had lain exposed for an extended period (certainly enough time to allow weathering/sun-bleaching to commence) prior to deposition within the pit. Two interpretations for the separation for the two fragments are suggested: the first indicates a degree of rough handling of the bone or post-mortem breakage occurring between collection and deposition. Alternatively, the post-mortem breakage may have occurred whilst the remains lay exposed, potentially with the two fragments being distributed away from each other, to account for their deposition in differing areas of the grave, although this could also simply be a result of the two fragments being thrown into the grave at opposite ends. These observations indicate the remains were subjected to varying taphonomic conditions in the aftermath following the individuals' deaths. Along with the incompleteness of the skeletal remains in general and the presence of at least partially articulated material, these observations provide strong evidence for at least some of the remains having been left exposed for an extended period of time prior to their inclusion with the burials. Thus, the general lack of scavenging appears strange given experimental findings regarding carnivore access to exposed remains (Blumenschine, 1995).

6.4.1.1 Burning

The evidence for burning is most prevalent within burial 110 and, in this case, is clearly associated with at least one attempt (possibly several) to set a fire within the pit. The presence of burned material suggests a high temperature fire, but these remains were relatively limited, with the majority of the skeletal elements in the grave unburnt, so a prolonged thermal event seems unlikely. The presence of other burnt bone indicating lower temperature burning is consistent with a focussed fire (Ellingham et al., 2015; Schmidt and Symes, 2007; Symes et al., 2014), whereby material on the margins would be less affected, although such material was found throughout the grave fill. The large number of iron nails, tacks and possible fittings suggests the possibility that a substantial amount of wood was deposited within the fill of the mass burial pit. One possible interpretation of this might be that scrap wood (with the iron nails/tacks embedded or otherwise not removed) was used as fuel for the fire within the pit. However, a general lack of evidence of preserved wood inhibits confirmation.

The limited and well-defined evidence of burning or charring observed in some of the bone elements in burial 101, some of which were articulated, is harder to explain (see **Error! Reference source not found.**). These burnt lesions clearly represented charred and blackened bone, but it was difficult to interpret how they may have occurred. The general burial matrix of burial 101 certainly did not show any evidence of a fire in situ. The only possibilities suggested included the potential dropping of a few hot coals onto the area of the remains or alternatively that these burnt elements were the result of either peri-mortem burning or burning associated with an earlier deposition site (e.g. a building fire or collapse). With regards to the latter, various forms of Greek fire were in use throughout the Crusader period by Christian, Muslim and Mongol armies and its use was not necessarily limited to siege situations as inferred from the great variety of weapons which integrated flammable materials (see Reinaud, 1850; Reinaud and Favé, 1845). Whether or not the charring observed in burial 101 (or indeed some of the burnt remains in burial 110) was attributed to weapons we are unlikely to know for certain, but the distinctive definition of the burning in this context deserves further scrutiny.

6.4.1.2 A lack of scavenging?

As noted briefly above, the general lack of evidence for scavenging of the human remains is surprising. A lack of animal scavenging has also been reported concerning the interpreted Bronze Age battlefield in the Tollense valley in Germany (Flohr et al., 2014; Jantzen et al., 2011). There, the lack of evidence for scavenging activity (specifically rodent gnawing and bite marks) was explained through reference to the depositional context – i.e. that remains were thrown into the river soon after the battle and then remained inaccessible (either underwater or buried in sediment). It is possible that a similar restriction of access may have inhibited scavenging animals such as rodents or larger carnivores from impacting the skeletal remains to any significant degree. The historical accounts pertaining to both the Mamlūk raid in 1253 and the sacking of the town by the Mongols in 1260 indicate substantial destruction to the town and its extant fortifications. As described in Chapter 5, there is also archaeological evidence for the deliberate destruction of the town's walls and associated features. This process of destruction may well have resulted in remains being temporarily covered prior to their collection and disposal within the mass grave deposits. Other factors may also have worked to preserve the remains. The high temperatures of summer (at which time both 13th century events occurred) had the potential to dry remains out rapidly, potentially making them less attractive to scavenging animals (see Figure 104).

Once the remains were placed next to or within the pit, the attendant processes (i.e. the burning that took place within the pit and the interpreted human activity associated with managing the remains and the fire) would most likely have deterred scavengers. Both burials 101 and 110 were subsequently sealed by a very compact layer of rubble measuring 50cm in thickness. This sealing deposit is considered to have been laid down quickly and relatively soon after the human remains were deposited, given the lack of any significant sedimentary layer sequence beneath the rubble and above the surface from which burial 110 is through to have been cut (Doumet-Serhal, 2016). It is feasible that the thick, overlying rubble layer might date to the destruction of the town's walls by the Mongols, but this would imply a six to seven-year period during which the burials were comparatively exposed. In such a situation, the question arises as to why the remains were not covered over fully or burial 101 interred within a similar pit. Worth noting is the high degree of compaction of sediments across the whole of the site and in the Bronze Age deposits, where throughout the period of the recent excavations, cuts through the deposits have been extremely difficult to identify.

6.4.1.3 Season of deposition

Both 13th century candidate events (the Mamlūk raid of 1253 and the Mongol retaliatory sacking of Sidon in 1260) are recorded to have taken place in mid-late summer. In contrast the Crusaders' successful siege of Sidon in 1110 took place in early to mid-winter, with the Crusaders taking possession on December 4th.

Within the forensic literature, contextual descriptors have been used to provide evidence for seasonality of deposition. These include locational context (e.g. under shelter/exposed to elements; within pre-existing features); and the presence of truncation, intercutting or re-use of features/interred material and other associated evidence. At Tuskulėnai in Lithuania, Jankauskas et al. (2005) interpreted the location of a group of mass burials within the interior floor plan of a military garage as being a direct result of the season in which the executions took place and burials were carried out. Here, the group buried inside the structure/garage appear to have been deposited during the winter months, when the ground and weather conditions outside would have made digging the graves exceptionally difficult. A similar interpretation was proposed concerning the archaeological remains of members of Napoleon's Grande Armée within a mass grave at Vilnius. The excavators reported how the remains were deposited within an existing artillery emplacement trench following the army's retreat from Russia in December 1812 (Signoli et al., 2004), when the local authorities were keen to clear the city streets of the dead amidst the threat of a typhus epidemic. Although the authors do not mention it, the extremely cold conditions at the time of the historically attested burial most probably inhibited, if not prohibited, the digging of large trenches suitable for accommodating such a large number of corpses (reportedly 37,000). The defensive trenches therefore offered a convenient solution – somewhat ironic given the French had dug the features the previous summer in advance of the disastrous campaign.

Seasonality of deposition has also been implied by Willey (1982: 158), who attributed the variation in representation of skeletal elements to a lengthy interlude between death and burial, with bodies left exposed and vulnerable to the effects of animal scavenging, in addition to cultural selection on the part of those carrying out burial.

The suggestion of an insect larval imprint within burial 110 (see Figure 53) may represent evidence of insect activity in association with the remains. Such larval activity implies carrion-associated insect egg-laying which would most likely occur in the presence of decomposing soft tissues, potentially close to the time of death. Such insect behaviour is heavily influenced by temperature and other environmental conditions, potentially indicative of the season. Potential insect activity also lends support to the hypothesis the remains were left exposed and unburied for at least twenty-four hours. However, a single possible imprint obviously cannot be taken as definitive evidence and any inferences would require identification to species level which has not been possible to date.

6.4.2 Who buried the bodies?

No clear evidence of a grave cut was observed with the deposit known as burial 101 and the remains appeared somewhat more spread out relative to the comparatively confined remains within burial 110, with no clearly-defined regular limit. At the time of excavation, it was suggested that the unusually angled positioning of context 4147 was the result of being forced into the edge of a pit. However, it is now thought the unnatural angulation of the spine was most likely an artefact resulting from the trauma observed in this individual (see Section 5.4). In contrast, burial 110 was characterised by a clearly delimited, rectilinear trench or pit, cut down into the Iron Age deposits lying at the base of the medieval fortification ditch.

The remains associated with burial 110 very slightly exceeded the limits of the top of the grave cut, and consequently there is some uncertainty concerning the original size and depth of the pit. Truncation and intercutting of burials are common in attritional cemeteries, and especially so in urban contexts. At St. Nicholas Shambles in London, only 36 skeletons remained complete out of a total of 234 graves identified during archaeological excavation, with half the individuals '*deficient in the head region*' (White, 1988: 29). Yet such destruction and loss is by no means inevitable in urban contexts: At Fishergate in York, a much greater degree of completeness was observed for the cemeteries there, with Stroud and Kemp (1993: 160) reporting that over half of the burials were 80% complete and under 10% of individuals were represented by less than a quarter of the body.

The limited evidence of burning within burial 110 is suggestive of at least one attempt to reduce the material already within the pit. Perhaps the pit was dug prior to collection of the remains being completed. Alternatively, the individuals responsible for digging the grave underestimated how deep/large they needed to make it or else they simply found the ground too hard. In any case, the close proximity of the remains representing burial 101 to the edge of the pit of burial 110, raises the distinct possibility that the original intention was to include these in the pit as well. The human remains in burial 101 generally presented a much greater degree of articulation than those within burial 110, with the possible interpretation that the smaller, more portable body parts were collected and deposited first within the pit and the larger sections piled up next to the pit to form burial

101, possibly to be processed in some way first (e.g. stripped of any useful items and materials and/or valuables).

Both the deposits clearly indicate human agency through the collection of the remains and their deliberate deposition within the grave pit of burial 110 at least. Wagner, (2015: 122) states that: "*…the social value placed on integrity depends on the community that has experienced the loss of life – namely, the surviving mourners.*" She goes on to emphasise that: "*…, not every culture requires a complete body, or a complete set of remains, to undertake ritual care for the deceased.*" This certainly reflects late medieval burial practices which indicate that whilst there may not have been an overt concern regarding the completeness or preservation of remains, the funerary process itself was highly important.

This western medieval mind-set is supported by Richard of Cornwall's actions whilst taking part in the Baron's Crusade (1239 – 1241). His efforts to repatriate the remains of those Crusaders slain in battle at Gaza eighteen months previously (November 1239) and have them buried in the cemetery at Ascalon (Wolff and Hazard, 1969, vol. II: 484) certainly appear to demonstrate a particular piety. This is qualified by a lack of details regarding how many bodies were buried, or if there was a selective process with perhaps only those remains of the nobility granted such reverence.

Burial by the Mamlūks or indeed by the Mongols seems highly unlikely given the contexts of these events as recorded in the contemporary sources. Even if they stayed longer in the vicinity than is indicated, the Mamlūks did not show a great deal of respect for their defeated opponents. In the aftermath of the battle of Mansourah in 1250, Joinville reports that several captives, including sick individuals were killed and their bodies thrown into the river ([§329], in Smith, 2008: 227). Joinville does make an intriguing observation regarding Mamlūk treatment of dead Christians following the surrender of Damietta (a condition of the release of Louis IX and others). He reports the sick inside the city were killed, describing how the Mamlūks made:

> *"… one pile of salt pork and another of dead people and they set fire to both; …"*

(Joinville, [§370], in Smith, 2008: 237)

These statements regarding the Mamlūks' behaviour towards the sick of Damietta are supported by the subsequent correspondence with the Mamlūk general, Faracataye (Joinville, [§401], in Smith, 2008: 244). An interpretation involving burial by Christians then is preferred, especially in light of the roughly east-west alignment of the long axis of the pit of burial 110. No evidence of burial shrouds was identified within either burial, but this is unsurprising given their incomplete state and the taphonomic processes suggested.

Daniell (2005) provides details on western Christian burial practices for the Late Medieval period in England, although clearly other accents to this relatively standardised behaviour were prevalent across Christian Europe. For those who could afford it, decisions were necessary concerning the potential return of the body to the individual's homeland, often involving long-distance transport of the remains (Knüsel, 2013: 275). With regard to such logistics no standard pattern or process has been observed. Individuals might be buried where they died; the whole body or simply only a token part of it might be transported back to a homeland; alternatively, the body might be divided, with separate parts removed to different final resting places, potentially far-removed from each other. Dismemberment and division of the body was therefore accepted, at least in some western traditions, prior to Pope Boniface VIII's condemnation of the practice at the turn of the 13th/14th century (Brown, 1981). Disinterment at a later date was also possible (Daniell, 2005: 80; Knüsel, 2013: 275). Associated with these efforts to repatriate bodies, other mortuary practices are also attested including: boiling of the body prior to transportation; removal of internal organs and stuffing; embalming; and salting (Daniell, 2005: 113; Knüsel, 2013: 275). However, Daniell's numerous citations relating to repatriation of the dead all involve high-status individuals, specifically aristocrats, a pattern confirmed by other authors (e.g. Knüsel, 2011; Knüsel, 2013; Knüsel et al., 2010), with little or no reference to the bodies of the less elevated social classes. He does note that in the Frankish states in the Near East, burial of the heart was a popular practice, most likely because it was easier to transport relative to a whole body, particularly if an individual's remains were to be transported a long distance (Daniell, 2005: 112).

Concerning the Sidon material, Daniell (2005:113) highlights the presence of only rudimentary archaeological evidence for the practice of dismemberment and division of the body, perhaps supporting the argument that the thin sharp force cut shown in Figure 96A-C represents interpersonal violence rather than mortuary processing. Worth noting with regard to potential processing of the remains, is the accumulation of articulated pelvic material observed in the upper layers at the eastern end of burial 110. A definite grouping of pelvic and spinal skeletal material, representing multiple individuals (some partially articulated and at least one fully articulated pelvis with vertebrae) was clearly evident (see

Figure 49 and Figure 51). This conspicuous concentration of multiple examples of this region of the body is strange and does not fit well with the otherwise relatively random distribution of disarticulated elements and partially articulated body parts within the grave out of burial 110. Suggested interpretations include the possibility of heavy wounds having completely transected some individuals or perhaps less severe wounds to the stomach region resulted in the connecting soft tissues of the central thorax deteriorating more rapidly, leaving only the most persistent joints remaining articulated by the time of collection and deposition. The latter is certainly possible within the bounds of the natural decomposition sequence also and has been predicted by archaeothanatological research (see Duday, 2006; Duday and Guillon, 2006). One final possibility, associated with the idea of stomach wounds, is that the bodies were deliberately compromised in the search for booty. The contemporary sources report both Crusaders and Muslims alike, mutilating the dead (as well as living prisoners) in the hope of retrieving any valuables that may have been previously swallowed in an attempt to keep them safe (see Fulcher of Chartres in Ryan (trans.), 1969: 122, 154-155).

Another significant aspect to medieval burial practices, at least from the standpoint of the Latin Church in England is that authorisation for burial had to be sought and given, usually by grant if not already established by tradition. Daniell (2005: 80) notes that in medieval England, the practice of burial was often strongly contested between a parish and its outlying chapels as it represented a profitable business for which there was an unending demand. Thus, for individuals to be buried in what, to our knowledge, was unconsecrated ground and with little in the way of ceremony, suggests a perfunctory response, perhaps due to limited financial resources or a lack of will or care. A further alternative explanation for the lack of ceremony, is a lack of time and/or perceived security. In either case of the Mamlūk raid or the Mongol assault, it is reasonable to assume whose carrying out the collection and burial of the remains would have been anxious to retreat to a safe haven as soon as possible, rather than remain exposed within the fortification ditch. Perhaps in parallel with this threat of renewed attack, emphasis may have been placed on repairing the town’s defences as soon as possible, with formal burial of the remains becoming less of a priority. The inclusion of several large animal skeletal elements as well as the number and variety of materials represented by the small finds, may indicate that the pit was also used as a convenient, temporary midden. It seems that attempts to reduce the corpse material in burial 110 were eventually abandoned along with the inferred original intention to bury the remaining bodies piled next to it. In this regard, a possible explanation for the thick, compact rubble layer overlying the deposits arises. Was this in fact a deliberate deposit necessary for the works on the town fortifications and did it simultaneously provide a neat solution for the final burial of such an unpleasant reminder of recent failings?

In any event, it can be argued that the lack of formal funerary treatment indicates the individuals represented in burials 101 and 110 derive from the lower social strata as the remains of those individuals of significant noble standing would most likely have been recovered from the battlefield and repatriated (Knüsel, 2013: Knüsel et al., 2010). This does, however, rely upon the assumption that the remains of such individuals were able to be recovered prior to advanced decomposition which is likely to have greatly hindered identification and recovery.

The single silver coin is intriguing. Aside from the very thin, silver finger ring and the copper alloy buckles, this was the only object of any specific monetary value recovered from either of the mass grave deposits. In the absence of any other coins, it seems somewhat odd that this lone *denaro* of Frederick II should be found on top of the remains in burial 110. Although being buried with grave good and particularly money was considered sinful, the archaeological evidence demonstrates clear exceptions (see Thompson, 2006). It is possible the coin's close association may be purely accidental, either included as part of the back fill of the grave or having somehow been dropped unintentionally onto the remains following their deposition. Another alternative is that it represents one form of crusader funerary behaviour. Evidence of coins has been found amongst formal burials of individuals from the Crusader period (Thompson, 2006: 53, 57, 62, 182). Such inclusions with burials are also suggested within the historical accounts. Joinville records the treatment accorded the bones of Count Walter of Brienne (who had died in captivity years before), when the remains were returned to his cousin, Margaret of Reynel, (the lady of Sidon) c. 1251:

> *"She [Margaret] arranged the service so that each knight offered a candle and a silver denier, and the king offered a candle and a gold bezant, all at her own expense."*

(Joinville, [§466], in Smith, 2008: 260)

The *denaro* or *denier* represented the smallest unit of currency used throughout most of Western Europe from the High to Late medieval period (Smith, 2008: 385). Does the coin therefore represent a token gesture then, for the benefit of those individuals denied an individual burial place, placed in at the last by agents empowered by king Louis? Perhaps it was included immediately prior to the sealing of the burials by the deliberate deposition of the rubble layer, in preparation for the renewal of Sidon's defences and the "*…high walls and large towers and … wide, clear ditches inside and out,…*" reported to have been left by Louis (Joinville [§615] in Smith, 2008: 298).

In summary, the peri-mortem trauma, the incompleteness of the remains and the taphonomic evidence indicating exposure of at least some of these remains prior to burial, suggests either a battle or a raid where the defeated side had been at a severe disadvantage. The number and severity of the trauma and the final state of the skeletal remains, suggests conflict was intense and brings to mind the scene described by Orderic Vitalis of the field of battle at Antioch, between the army of the First Crusade and the Muslim forces attempting to relieve the citadel in 1098:

> *"Loud was the clash of arms, and sparks were struck from the brazen helmets; wounds followed wounds and the earth was dyed with purple blood. On every side were seen intestines torn out, decapitated heads and dismembered bodies."*

(Orderic Vitalis, Bk. 9, Ch. 9 in Forester, 1854: 115)

7 CONCLUSIONS

Results of the macroscopic analyses demonstrate the human remains from burials 101 and 110 exhibit a broadly consistent pattern of trauma indicating the individuals from these two deposits died under similar circumstances and were most likely involved in an intense battle which led to their deaths. Despite the limited number of individuals represented within the crusader mass grave deposits under consideration, their commingled nature and the high degree of disarticulation and fragmentation, their significance should not be understated. These findings constitute unique new osteological data representing the largest conflict-related mass grave (MNI = 25) directly dated to the period of the Crusades in the Latin East yet to come to light.

The location and type of individual wounds in these remains as well as the overall pattern of their distribution provides significant insight concerning late medieval warfare as it was experienced by those fighting in the Crusades. The results presented here contribute to the verification of aspects of crusader warfare as well as daily life and society within the Frankish states, as described in both contemporary accounts and subsequent associated histories.

The isotopic results represent novel evidence for the diversity of crusader society, identifying three differentiated groups, corroborating the historical records which describe both regular influxes of new arrivals to the Crusader states and the presence of settled migrants. In contrast, the current sample does not reflect the numbers of casualties reported in the historical accounts, lending some credence to the current prevailing view of historians that the authors of these contemporary and later sources cannot be relied upon concerning the numbers of those involved in late medieval warfare.

Most significantly, however, the human remains and the traumata observed do demonstrate remarkable consistency with the contemporary sources, both written and iconographic, as regards the intensity and horror of battle.

The Sidon Crusaders therefore represent the only direct and irrefutable evidence for lethal inter-group violence in the context of crusader warfare in the Levant to date.

Afterword

DNA analyses carried out by Haber et al. (2019) have recently confirmed the genetic diversity of the individuals from the mass graves at Sidon, also identifying three groups, with individuals of recent European ancestry, those of local eastern ancestry and two individuals with mixed ancestry, indicating the Crusaders clearly mixed with the local populations to some degree and perhaps not only at the higher levels of society. Thus, the isotopic data presented in this thesis, supported by the DNA analyses, also demonstrate that crusader society was not necessarily made up from a universal western Christian population and suggests popular stereotypes concerning the Crusades and those involved are misplaced.

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APPENDIX A1: The Eastern Armies

Table 17: Notable groups contributing to the Muslim armies. Source: Nicolle, 1979.

Ethnic group	**Broader ethnicity**	**Regional association**
Banu Munqidh	Arab	From Shaizar
Bedouins	Arab	From Syria and Egypt
Judham	Arab	From the Southern Levant/ Northwestern Arabia
Farghāna Turks	Turk	From region north of Amu Darya river (modern equivalent: Uzbekistan)
Khorasani	Turk	Iranians from region south of Amu Darya river (modern equivalent:Turkmenistan)
Turkish Mamluks - Farāghina and Ushrūsiyya - Turco-Iranian Khwārazmians - Others	Turk	- From Farghana region/ Transoxiana - From southern Iran - From other regions beyond *Dār al-Islām*
"Agulani"	Other	Possibly either Albanians or Aghovanians from Caucasus region
Daylāmis	Other	Iranians from mountains south of Caspian Sea
Kurds	Other	Kurdistan

APPENDIX A2: Historical Glossary

Barbican: An outer defensive work around a castle or other fortification, of various types: a wall, a tower, a gatehouse, etc. (Crawford, 2003).

Bordon: A slender dagger made for thrusting (Crawford, 2003).

Buches Wood for construction, in various forms, including bundles of faggots or wooden revetments or coverings. Used to screen troops or siege engines (Crawford, 2003).

Carabohas: A type of trebuchet, whose name derives from its Arabic nickname, 'black camel' (Chevedden, 2004; Crawford, 2003).

Chat: Literally, 'cat'; a wooden siege fortification, used to protect besiegers or besieged from attack (Crawford, 2003).

Emir: A Muslim ruler or high officer (Crawford, 2003).

Fosse: Moat or ditch (Crawford, 2003).

Lamiera: pl. lamieri. A cuirasse (q.v.) made of iron or other metal fixed to leather or cloth (Crawford, 2003).

League: A measurement of distance, varying from 2.4 to 4.6 miles (often around 3 miles) (Crawford, 2003).

Mamluks: Muslim soldiers, originating as boys (usually Caucasian or central Asian) who were enslaved and sold to Muslim Egypt. There they were forcibly converted to Islam and trained as warriors. When they completed their training, they were formally freed; thereafter they formed an elite regiment in the army.

The Mongol conquests in Asia during the first half of the 13th century resulted in a sharp rise in the number of children sold into slavery, so that by the middle of the century the number of mamluks in the service of the Ayyubid regime in Egypt had grown significantly. In 1250, during the Seventh Crusade, they overthrew the Ayyubid sultan and ruled Egypt (and, from 1260, Syria) as a self-perpetuating military junta until the 16th century (Crawford, 2003).

Mohammedans: Archaic term for Muslims, based on the misperception that they worshipped Muhammad (Crawford, 2003).

Poulain: Generally taken to mean someone born in the Latin East of Western parentage (cf. the modern Israeli sabra). M. R. Morgan believed that it had acquired a pejorative connotation by at least the 14th century (see her 'The Meanings of Old French Polain, Latin Pullanus', Medium Aevum 48 (1979), pp.40-54), though its use in the 'Templar' (§454) would not seem to support this interpretation (Crawford, 2003).

Quarrels: Crossbow bolts (Crawford, 2003).

Roncin: A horse of inferior quality, usually used as a pack animal. Less desirable than a palfrey, which was a good-quality riding horse, or a destrier (q.v.) (Crawford, 2003).

Sergeant: Either a foot-soldier or, from the late twelfth century, a mounted warrior (but lacking the social status of a knight). Not the non- commissioned officer of modern usage. The word is derived from a word for 'servant' (Crawford, 2003).

Tartars: The Frankish name for Mongols (Crawford, 2003).

Turcopoles: Generally considered to have been native auxiliary troops, perhaps the offspring of Franks and native women. Turcopoles were mounted warriors who fought armed and equipped like the Turks. The name probably extended to anyone equipped in this way, irrespective of birth or ethnic background (Crawford, 2003).

APPENDIX A3: Human remains with individual context numbers

Table 18: Summary of human remains from burial 101 attributed individual context numbers.

Context	Year	Layer	Description
4146	2009		Relatively compact fill with no obvious burning evidence apart from the burned and blackened human remains, which demonstrate no obvious pattern of distribution themselves. Only a single, broken, small figurine was retrieved from the top of the fill.
4147	2009	1	Also known as 'Torso C': Upper half of body (articulated), consisting of majority of cranium (excepting parietals, fragmented), mandible (fragmented) and hyoid; the almost complete vertebral column (excepting L5 vertebra, fragmented), all ribs (fragmented), the left clavicle (medial 3/4 only), the right scapula (fragmented but almost complete excepting lateral coracoid tip), the right clavicle (lateral 3/4 only), the right upper limb (complete excepting pisiform and triquetral carpals, MC5 and 5th distal hand phalanx, humeral head fragmented). The cranium was lying on its right side, facing roughly S, the extant vertebral column aligned N-S, but flexed unnaturally at 90° in the NE limit of the burial deposit. The extant, partially extended right upper limb is lying towards the SW, with the midshafts of the radius and ulna overlying lower limb (4163, also known as 'Leg F')
4148	2009	1	Also known as 'Torso A': Upper Torso (articulated), consisting partial vertebral column (T4-T12 vertebrae, neural arches highly fragmented) and associated left and right rib shaft fragments

4149	2009	1	Also known as ‘Arm A’: Left Upper limb (articulated), consisting of left humerus (distal epiphysis only, excepting capitulum, fragmented), left radius (fragmented but complete) and left ulna (fragmented but complete), left carpals (complete), left metacarpals (MC1-MC5) and associated hand phalanges (complete excepting 5th intermediate and distal hand phalanges)
4150	2009	1	Also known as ‘Skull A’: Cranium and neck (articulated), consisting of majority of cranium (excepting cranioviscera, left frontal and right temporal, fragmented); cervical vertebrae (C1-C6, broken/fragmented)
4151	2009	1	Also known as ‘Torso B’: Upper torso (articulated?), consisting of associated (/articulated?) grouped left and right ribs (broken/fragmented but many complete); Ribs +?
4152	2009		Also known as ‘Foot A’: Right Foot (articulated), consisting of right tarsals (almost complete, including calcaneal and talar fragments only), right metatarsals (MT1-MT5), majority of associated foot phalanges (excepting right 1st proximal foot phalanx, 1 intermediate and 2 distal foot phalanges); and some associated hand bones
4153	2009	1	Also known as ‘Leg C’: Right Lower limb (articulated), consisting of right femur (distal 1/2 only), right patella (complete), right tibia (fragmented, proximal 1/2 only) and right fibula (proximal 1/2 only)
4154	2009	1	Also known as ‘Leg A’: Left Lower limb, (articulated), consisting of left femur (fragmented but complete), left patella (medial 2/3 only), left tibia (fragmented, proximal 1/3 only) and left fibula (fragmented, proximal 1/3 only)

4155	2009	1	Also known as 'Leg B': Right Lower limb and foot (articulated), consisting of right femur (distal 1/2, fragmented), right patella (complete), right tibia (fragmented but complete) and right fibula (fragmented but complete), right tarsals (including calcaneal, talar and cuneiform fragments, partial navicular and complete cuboid only), right metatarsals (MT4-MT5) and some associated foot phalanges
4156	2009	2	Also known as 'Arm B': Left Upper limb (articulated) belonging to a subadult, consisting of left humerus (distal 1/2 only), left radius (broken but complete excepting distal styloid process, extant distal epiphysis appears in process of fusion), left ulna (broken but complete, distal epiphysis open and unfused), left carpals (complete) and left metacarpals (MC1-MC5) and majority of associated hand phalanges (excepting 1 intermediate hand phalanx and left 1^{st} distal hand phalanx)
4157	2009	2	Also known as 'Arm C': Left Shoulder and upper limb (articulated), consisting of left clavicle (fragment of midshaft only), left scapula (fragments representing glenoid fossa, coracoid process and acromion only), majority of left humerus (fragments, excepting majority of humeral head), left radius and left ulna (proximal 1/4s only)
4158	2009	1	Also known as 'Leg D': Left Lower limb (articulated), consisting of left femur (complete but fragmented), left tibia (complete but fragmented) and left fibula (complete but fragmented)

4159	2009	1	Also known as 'Torso D': Torso and both shoulders (articulated), right scapular fragments (excepting coracoid process), majority of right clavicle (excepting medial aspect of midshaft), majority of left scapula (excepting lateral acromial tip), majority of left clavicle (excepting medial aspect of midshaft), left humerus (humeral head only), corpus sterni, manubrium, left ribs 1-5/6, majority of vertebral column (including C2-T1 and T8-L5 vertebrae), majority of the sacrum (fragmented), majority of left *Os coxae* (excepting pubis), majority of right *Os coxae* (excepting pubis), left femur (proximal 1/2 only)
4160	2009	2?	Also known as 'Pelvis A': Pelvis (articulated) probably belonging to a subadult (older adolescent), consisting of left *Os coxae* (fragmented but complete) and right *Os coxae* (fragmented but complete), sacrum (fragmented but complete), basal vertebral column (L2-L4 vertebrae at least, fragmented). Iliac crests of both ossa coxae largely open/unfused or in early stages of fusing; Ischial tuberosities in process of fusing, but with at least some of the epiphyses still open; S5 sacral body not fully fused; S1 body also possibly not fully fused, but not certain
4161	2009	2	Also known as 'Leg E': Left Lower Limb and foot (articulated), consisting of left tibia (distal 1/3 only) and left fibula (distal 1/3 only), left tarsals (including calcaneal, talar and navicular fragments, cuneiforms and cuboid complete), left metatarsals (MT1-MT5) and majority of associated foot phalanges
4162	2009	2	Also known as 'Arm D': Left Upper limb (articulated), consisting of left humerus (distal 1/2 only, fragmented), left ulna (fragmented but almost complete), left radius (fragmented but almost complete), left carpals (complete), left metacarpals (MC1-MC5, majority fragmented) and associated hand phalanges

4163	2009	2	Also known as 'Leg F': Left Lower limb and foot (articulated), consisting of left tibia (fragmented but almost complete) and left fibula (fragmented but almost complete), left tarsals (almost complete, calcaneus and cuboid fragmented), left metatarsals (MT1-MT5, fragmented) and associated proximal foot phalanges
4164	2009	1	Also known as 'Skull B': Majority of cranium (fragmented but complete excepting cranioviscera and zygomatics); C3 vertebra; some ribs; some upper thoracic vertebrae (T1-T3 vertebrae) also recorded 'near Skull B'
4165	2009	2	Also known as 'Sacrum A': Sacrum (highly fragmented but almost complete) and L5 vertebra (articulated). N.B. Auricular surface matched to left *Os coxae* from B.110 (Quad-B_L2); L5 vertebra may possibly also match ('Torso C') which is missing L5
4166	2009	1	Also known as 'Arm E': Left Shoulder (articulated), consisting of left scapula (fragmented but almost complete, excepting acromion and lateral tip of coracoid), left clavicle (lateral 1/2 at least), left humerus (proximal 1/2 excepting humeral head, fragmented)
4167	2009	2	Also known as 'Ribs A': Group of Right Ribs (articulated) (- ribs 2-c.11, fragmented).
4168	2009	3	Also known as 'Arm F': Right Upper limb and hand (articulated), consisting of right humerus (complete, humeral head fragmented), right radius (complete, distal 1/3 fragmented) and right ulna (complete, distal 1/3 fragmented), right carpals (complete excepting pisiform), right metacarpals (MC1-MC5) and all associated hand phalanges

4169	2009	3	Also known as ‘Leg G’: Left Hip and lower limb (articulated), consisting of left *Os coxae* (fragmented but almost complete excepting pubis), left femur (fragmented but almost complete), left patella (complete), left tibia (proximal head fragments only)
4170	2009	2	Also known as ‘Pelvis B’: Pelvis (articulated), consisting of
4171	2009	2	Also known as ‘Leg H’: Right Lower limb (articulated), consisting of right femur (fragmented but complete), right patella (complete), right tibia (fragmented but almost complete), right fibula (distal 1/2 only, fragmented), right tarsals (complete), right metatarsals (MT1-MT5), and almost all associated foot phalanges (excepting 1 proximal foot phalanx and 1 intermediate foot phalanx)
4172	2009	3	Also known as ‘Leg I’: Left Lower limb (articulated) probably belonging to a younger adult or older adolescent, consisting of left femur (fragmented but complete), left patella (complete) left tibia (proximal 1/2 only, fragmented). Distal epiphyseal line still evident/open in at least one area in left femur.
4173	2009	3	Also known as ‘Leg J’: Right Hip and lower limb (articulated), consisting of right *Os coxae* (ilium only, fragmented), right femur (fragmented but complete), right patella (superior medial aspect only)
4174	2009	3	Also known as ‘Arm G’: Right Shoulder and upper limb (articulated), consisting of right scapula (lateral border, inferior glenoid fossa and inferior angle only, fragmented), right humerus (distal 1/2 only, fragmented), right ulna (proximal 1/2 only, fragmented) and right radius (proximal 1/2 only)

4175	2009	2	Also known as 'Pelvis C': Pelvis and lower limbs (articulated), consisting of basal vertebral column (including L1-L5 vertebrae), associated rib fragments, left *Os coxae* (fragments), right *Os coxae* (fragments), sacrum (fragmented), right femur (proximal 2/3 only, fragmented), left femur (proximal 1/3 only)
4176	2009	2	Also known as 'Arm H': Right Shoulder and upper limb (articulated), consisting of right scapula (fragmented but almost complete excepting medial blade, highly fragmented), right clavicle (lateral 1/3 only), right humerus (fragmented but complete), right ulna (proximal 1/2 only, fragmented), right radius (proximal 1/2 only). (4176) was prone, flexed at elbow anteriorly

Table 19: Summary of human remains from burial 110 attributed individual context numbers.

Context	Layer	Grid	Element	Fused/ Unfused?	Completeness
4204	4?	A	Humerus (R.)		Incomplete: humeral head missing
4204	4?	A	Ulna (R.)		Complete
4204	4?	A	Radius (R.)		Complete
4204	4?	A	Carpals (R.)		Incomplete: trapezoid, lunate, trapezium, capitate and triquetral present
4204	4?	A	MC2-MC4		
4206	4	B	*Os coxae* (L.)		Incomplete: Ischium and part of Ilium present
4206	4	B	Femur (L.)		Incomplete: proximal half present
4207	4,5	G/H	Humerus (R.)		Complete
4207	4,5	G/H	Ulna (R.)		Complete
4207	4,5	G/H	Radius (R.)		Complete
4209	5	C	Tibia (L.)		Complete
4209	5	C	Fibula (L.)		Complete
4209	5	C	Calcaneus (L.)		Complete
4209	5	C	Talus (L.)		Complete
4209	5	C	Tarsals (L.)		Incomplete: cuboid missing
4210	5	C/D	Femur (R.)		
4210	5	C/D	Patella (R.)		
4210	5	C/D	Tibia (R.)		

4210	5	C/D	Fibula (R.)		
4210	5	C/D	Talus (R.)		
4211	4, 5	A	T11-L5		Complete
4211	4, 5	A	Sacrum		Complete
4212	5	A	L2-L5		
4212	5	A	Sacrum		Complete
4212	5	A	*Os coxae* (R.)		Complete
4212	5	A	*Os coxae* (L.)		Complete
4212	5	A	Femur (L.)		Incomplete: proximal half of shaft present, not femoral head
4213	4, 5, 6, 7	A	Cranium		Complete
4213	4, 5, 6, 7	A	Mandible		Complete
4214	5	E/F	Humerus (R.)		Complete
4214	5	E/F	Ulna (R.)		Incomplete?
4214	5	E/F	Radius (R.)		Incomplete?
4215	5	H	Calcaneus (R.)		Complete
4215	5	H	Talus (R.)		Complete
4215	5	H	Tarsals (R.)		Incomplete: only lateral cuneiform missing
4215	5	H	MT1-MT5		
4216	5,6,7	H	Thoracic vertebrae		
4217	5	E	Humerus (R.)		

4217	5	E	Ulna (R.)		
4217	5	E	Radius (R.)		
4217	5	E	Carpals (R.)		Incomplete: Pisiform and lunate missing
4218	5	G/H	(R?) hand		Incomplete: Only triquetral(?) and phalanges present
4219	5	E	Carpals (L.)		Incomplete: Triquetral, lunate, pisiform and capitate missing
4220	5	C	Carpals (R.)		Incomplete: Only hamate and trapezoid present
4220	5	C	MC4-MC5		
4221	5	B	Talus (R.)		
4221	5	B	Tarsals (R.)		Incomplete: Intermediate cuneiform missing
4223	5	A	Carpals (R.)		Incomplete: Only capitate and scaphoid present
4224	5	A	Carpals (L.)		Incomplete: Only scaphoid present
4225	5	B	Thoracic vertebrae		
4226	6	A	Calcaneus (R.)		Complete
4226	6	A	Tarsals (R.)		Incomplete: Only medial cuneiform and navicular present
4226	6	A	MT2-MT4(?) (R.)		
4227	6	D	L1-L4		
4228	6,7	A	Scapula (R.)		Incomplete: Glenoid fossa and coracoid process present
4228	6,7	A	Clavicle (R.)		Incomplete: Medial half present
4228	6,7	A	Humerus (R.)		Incomplete: proximal 1/3 present

4229	6	C	Ribs (R.)		
4230	6	C/E	Ribs (L.)		
4231	6	E	Tibia (R.)		
4231	6	E	Fibula (R.)		
4232	6	E	Ribs (R.)		
4233	6	G	Calcaneus (R.)		Complete
4233	6	G	Talus (R.)		Complete
4233	6	G	Tarsals (R.)		Complete
4233	6	G	MT1-MT4 (R.)		
4234	6	H	Cranium		Incomplete: Occipital and parietals missing
4234	6	H	Mandible		
4234	6	H	C2		
4235	6	F	Tarsals		Incomplete: Navicular and cuboid missing
4235	6	F	MT1-MT3		
4236	5,6	F	Tibia (L.)		Complete
4236	5,6	F	Fibula (L.)		Complete
4236	5,6	F	Calcaneus (L.)		Complete
4236	5,6	F	Talus (L.)		Complete
4236	5,6	F	Tarsals (L.)		Incomplete: Only Navicular and cuboid present
4237	6	H	Humerus (R.)		Incomplete: humeral head missing
4237	6	H	Ulna (R.)		Incomplete: Proximal 2/3 present

4237	6	H	Radius (R.)		Incomplete: Proximal 2/3 present
4238	6	A	T12-L4		
4239	7	B	Femur (R.)		Incomplete: Distal 4/5 present
4239	7	B	Patella (R.)		Complete
4239	7	B	Tibia (R.)		Incomplete: Proximal 1/2 present
4239	7	B	Fibula (R.)		Incomplete: Proximal 1/2 present
4241	6	A			
4243	6	D	Ribs (L.)		
4244	6	F	Patella (R.)		Complete
4244	6	F	Tibia (R.)		Complete
4245	7	A	Femur (R.)		Incomplete: Distal epiphysis present only
4245	7	A	Patella (R.)		Complete
4245	7	A	Tibia (R.)		Incomplete: Distal joint end missing
4245	7	A	Fibula (R.)		Incomplete: Distal joint end missing
4246	6,7,8,9	A/B	Humerus (R.)		Complete
4246	6,7,8,9	A/B	Scapula (R.)		Complete
4246	6,7,8,9	A/B	Clavicle (R.)		Complete
4247	7,8,9	B	Cranium		Incomplete: Frontal, cranioviscera missing
4247	7,8,9	B	Mandible (R.)		Incomplete: Fragment of body present only
4247	7,8,9	B	Cervical vertebrae		Incomplete: Fragment of body present only

4248	7	D	Scapula (R.)		Incomplete: Glenoid fossa, acromion and coracoid process present
4248	7	D	Clavicle (R.)		Complete
4248	7	D	Humerus (R.)		Incomplete: Proximal half present
4249	7,8,9,10	D	Femur (R.)		Complete
4249	7,8,9,10	D	Patella (R.)		Complete
4249	7,8,9,10	D	Tibia (R.)		Incomplete: Proximal 1/3 present
4250	7	D	Tarsals (R.)		Complete
4250	7	D	MT1-MT5 (R.)		
4251	7	D/F	Humerus (L.)		Incomplete: Humeral head missing
4251	7	D/F	Ulna (L.)		Incomplete: Proximal 2/3 present
4252	7	C/D	Ribs (R.)		
4253	7	E	Tibia (R.)		Complete
4253	7	E	Fibula (R.)		Complete
4253	7	E	Calcaneus (R.)		Complete
4253	7	E	Talus (R.)		Complete
4253	7	E	Tarsals (R.)		Complete
4253	7	E	MT2-MT5		
4254	7	G	Femur (R.)		Incomplete: Distal half present
4254	7	G	Tibia (R.)		Incomplete: Proximal 1/3 present
4255	7	H	Ribs (R.)		

4256	7	H	Calcaneus (R.)		Complete
4256	7	H	Talus (R.)		Complete
4256	7	H	Tarsals (R.)		Incomplete: Navicular missing
4257	7	F	Humerus (L.)		Complete
4257	7	F	Ulna (L.)		Complete
4257	7	F	Radius (L.)		Complete
4258	7	F	Carpals (L.)		Incomplete: pisiform and trapezium missing
4258	7	F	MC1-MC5		
4259	7	C	C3-L2		
4260	7	C	Scapula (L.)		Incomplete: Glenoid fossa, acromion and coracoid process present
4260	7	C	Clavicle (L.)		Incomplete: Medial 2/3 present
4260	7	C	Thoracic/ cervical vertebrae		
4264	7	D	Carpals (R.)		Incomplete: Only pisiform present
4264	7	D	MC4-MC5 (R.)		
4265	7	A	Ulna (L.)		Incomplete: midshaft present
4265	7	A	Radius (L.)		Incomplete: Proximal half present
4266	8	A	Femur (R.)		Incomplete: Distal 1/4 present
4266	8	A	Tibia (R.)		Incomplete: Proximal 1/3 present
4267	8	A	Ribs (R.)		

4268	8	A/C	Ulna (R.)		Incomplete: Distal end present
4268	8	A/C	Radius (R.)		Incomplete: Distal end present
4268	8	A/C	Carpals		Incomplete: Scaphoid and Pisiform missing
4268	8	A/C	MC2-MC5		
4269	8	A	Scapula (L.)		Incomplete: Glenoid fossa, acromion and coracoid process present
4269	8	A	Clavicle (L.)		Complete
4269	8	A	Humerus (L.)		Incomplete: Proximal half present
4270	8	E	Carpals (R.)		Incomplete: Only triquetral present
4270	8	E	MC1-MC2, MC4		
4271	8	E	Cranium		Incomplete: Only Occipital, temporals and parietals present
4271	8	E	C2-C5		
4272	8	E	Ribs (R.)		
4273	8,9	E	Ulna (R.)		Complete
4273	8,9	E	Radius (R.)		Incomplete: Proximal 1/3 present
4274	8	F	Humerus (L.)		Complete
4274	8	F	Ulna (L.)		Complete
4274	8	F	Radius (L.)		Complete
4275	8	D/F	Femur (L.)		Complete
4275	8	D/F	Patella (L.)		Complete
4275	8	D/F	Tibia (L.)		Incomplete: Proximal 1/4 present

4279	9	H	Radius (L.)		Incomplete: Distal 1/4 present
4279	9	H	Carpals (L.)		Incomplete: Triquetral and lunate missing
4280	9	F	Calcaneus (L.)		Complete
4280	9	F	Talus (L.)		Complete
4280	9	F	Tarsals (L.)		Incomplete: Cuboid and Navicular present
4281	9	E	Carpals (R.)		Incomplete: Only pisiform missing
4281	9	E	MC1-MC5		
4282	9	F	Carpals (L.)		Incomplete: Trapezium and trapezoid missing
4282	9	F	MC2-MC4		
4283	7,8,9	F	*Os coxae* (R.)		Incomplete: Ischium and part of inferior Ilium present
4283	7,8,9	F	Femur (R.)		Incomplete: Proximal half present
4284	7,8,9	D/F	Femur (L.)		Complete
4284	7,8,9	D/F	Patella (L.)		
4284	7,8,9	D/F	Tibia (L.)		Incomplete: Proximal 1/3 present
4284	7,8,9	D/F	Fibula (L.)		
4285	9	D	Carpals (L.)		Incomplete: Capitate, scaphoid, trapezium and trapezoid present
4286	9	D	MC1		
4287	9	C	Fibula (R.)		Incomplete: Distal end present
4287	9	C	Calcaneus (R.)		Complete
4287	9	C	Talus (R.)		Complete

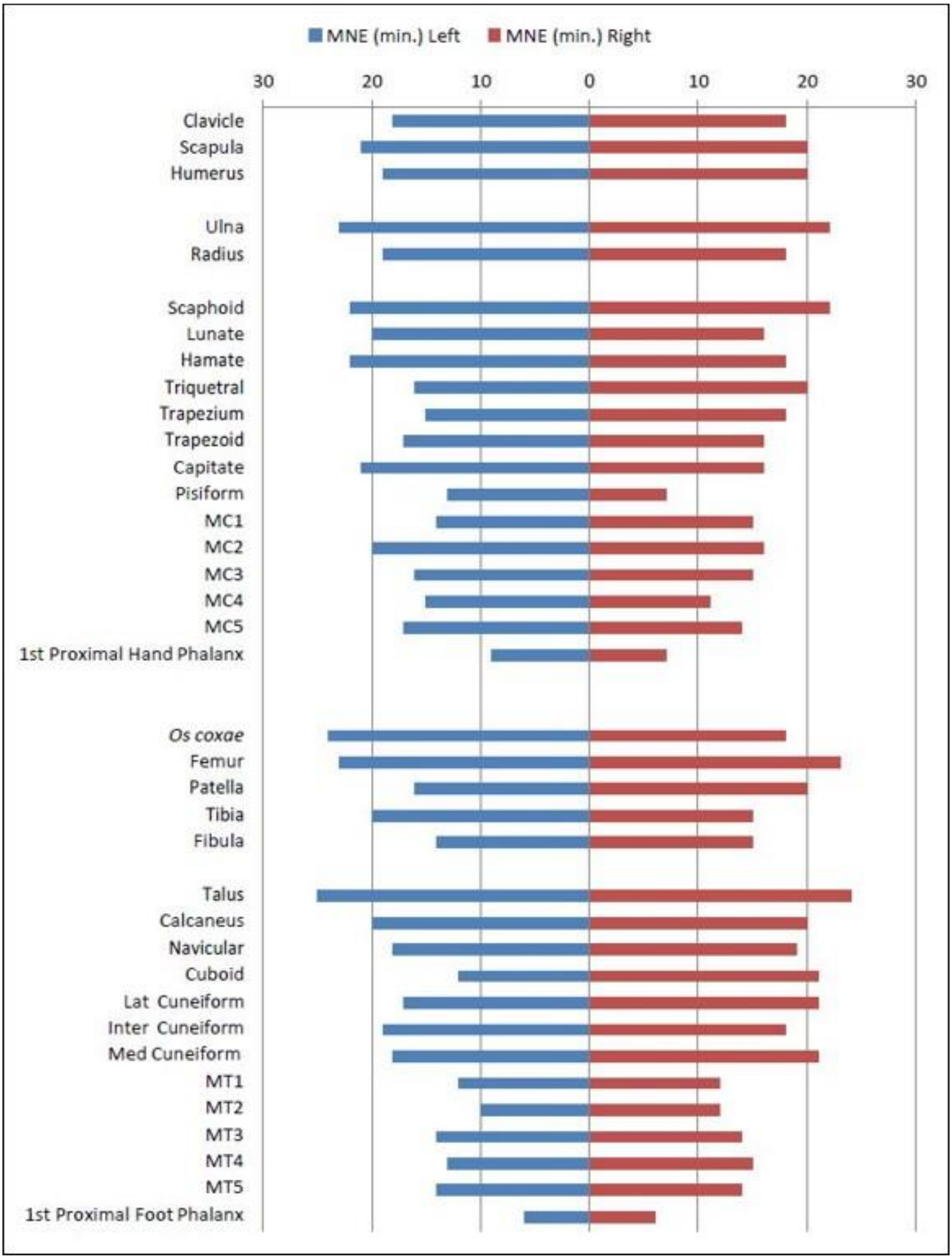
4287	9	C	Tarsals (R.)		Incomplete: Cuboid and lateral cuneiform missing
4287	9	C	MT4-MT5(?)		
4288	9	A	Carpals (R.)		Incomplete: Scaphoid and triquetral missing
4289	9,10	A	Ulna (L.)	Fusing	Complete
4289	9,10	A	Radius (L.)	Fusing	Complete
4289	9,10	A	Carpals (L.)		Complete
4289	9,10	A	MC1-MC5		
4290	9	D	MT1-MT2		
4291	7,8,9	D/F	Femur (L.)		Complete
4291	7,8,9	D/F	Patella (L.)		Complete
4291	7,8,9	D/F	Tibia (L.)		Incomplete: Proximal 1/4 present
4292	8,9	C/D	Humerus (R.)		Incomplete: Distal end present
4292	8,9	C/D	Ulna (R.)		Incomplete: Proximal 1/3 present
4292	8,9	C/D	Radius (R.)		Incomplete: Proximal 1/3 present
4293	10	D/F	Femur (L.)		Complete
4293	10	D/F	Patella (L.)		Complete
4294	10	C	Carpals (R.)		Incomplete: Only lunate present
4294	10	C	MC1, MC3, MC5		
4295	7,8,10	E	Femur (L.)		Complete
4295	7,8,10	E	Patella (L.)		Complete

4296	10	F	Ribs (R.)		
4296	4?	A	Humerus (R.)		Incomplete: humeral head missing
4297	4?	A	Ulna (R.)		Complete
4297	4?	A	Radius (R.)		Complete
4298	11	B	MT2(?)		
4299	2,3	B	Clavicle (R.)		Complete
4299	2,3	B	Scapula (R.)		Complete
4299	2,3	B	Ribs (R.)		
4299	2,3	B	Vertebrae		
4299	2,3	B	Rib (L.)		
4300	2	B	*Os coxae* (R.)		Complete
4300	2	B	*Os coxae* (L.)		Complete
4300	2	B	Sacrum		Complete
4300	2	B	T11-L5		Complete
4300	2	B	Cg1		Complete
4301	Top?	C	Cranium		Incomplete: Parietals and Frontal and cranioviscera missing
4302	Top?	B	T10-L5		
4303	Top,2	B	Carpals (L.)		Incomplete: Hamate, trapezium, trapezoid and pisiform present
4303	Top,2	B	MC2-MC5		
4304	Top?	D	Cranium		Incomplete

4304	Top?	D	C1-C5		
4305	Top?	D	Ulna (R.)		Complete
4305	Top?	D	Radius (R.)		Complete
4306	2	C	Ulna (R.)		Complete
4306	2	C	Radius (R.)		Incomplete: proximal radius/head missing
4309	2	D	L3-L5 vertebrae		
4309	2	D	Sacrum		Complete
4309	2	D	Cg1		Complete
4310	Top?	B	Scapula (L.)		Complete
4310	Top?	B	Clavicle (L.)		Incomplete: Medial end present
4310	Top?	B	Manubrium		Incomplete: only burnt fragments present
4311	2	D	*Os coxae* (L.)		
4311	2	D	Femur (L.)		Incomplete: proximal half present
4312	2	D	*Os coxae* (L.)		Complete
4312	2	D	Sacrum		Complete

APPENDIX A4: Postcranial MNI

Table 20: Summary of MNI represented by individual counts of postcranial bone elements.



APPENDIX A5: Demography

Table 21: Ageing of pelvic fragments recovered from burials 101 and 110, using three methods.

Burial No.	Context ID	Bone element	Auricular surface					Pubic symphysis			
			Lovejoy et al. (1985)		Buckberry and Chamberlain (2002)		Boldsen et al. (2002)	Brooks and Suchey (1990)		Dudzik and Langley (2015)	Boldsen et al. (2002)
			Age Cat.	Age range	Age Cat.	Age range		Age Cat.	Age range		
110	4180_Quad_A_Top (Match = 4307)	*Os coxae* (L.)*	4 (-6)	35-49	4	29-81	22.2-76.3 (44.9)	-	-	-	-
110	4300_(Quad_B_L2)	*Os coxae* (L.)	5	40-44	4	29-81	22.9-86.4 (49.2)	5	27-66	Cat. 3 (33-40)	28.4-67.6 (41.8)
110	4300_(Quad_B_L2)	*Os coxae* (R.)	5?	40-44	5	29-88		5	27-66	Cat. 3 (33-40)	
110	4180_Quad_B_L2 (Match? = 4165)	*Os coxae* (L.)	5	40-44	5?	29-88?	25.6-96.7 (56.4)	-	-	-	-
110	4180_Quad_D_L2)	*Os coxae* (L.)	5 (-7)	40-59	7	53-92	25.6-96.7 (56.4)	-	-	-	-
110	4311_(Quad_D_L2) (Match? = 4309)	*Os coxae* (L.)	5-7	40-59	5	29-88	22.0-67.0 (39.8)	-	-	-	23.2-73.7 (37.0)
110	4311_(Quad_D_L2) (Match? = 4309)	*Os coxae* (R.)	4-5	35-44	5	29-88		4	23-57	Cat. (2) (min.25-32)	

110	4180_Quad_D_L2	*Os coxae* (L.)	-	-	-	-	-	Min.4? X	23- 57?	Cat. (2) (min.25-32)	23.6-57.4 (34.4)
110	4212_(4203_A_L5)	*Os coxae* (L.)	Min. 4	35+	5?	29-88	20.0-85.7 (46.3)	5	27-66	Cat. 3 (33-40)	29.0-82.1 (47.2)
110	4212_(4203_A_L5)	*Os coxae* (R.)	-	-	-	-	-	4-5	23-66	Cat. 3 (33-40)	
110	4203_A_L6	*Os coxae* (L.)	4 (-7)	35-59	5	29-88	38.4-110.0 (80.0)	-	-	-	-
110	4203_A_L7	*Os coxae* (L.)	4-6	35-49	Min.4	29-81+	28.0-88.2 (55.8)	-	-	-	-
110	4203_A_L7 (intrusive)	*Os coxae* (R.)	-	-	-	-	-	3-5	21-66	Cat. (2) (min.25-32)	23.6-57.4 (34.4)
110	4278_A-B_L9	*Os coxae* (L.)	-	-	-	-	-	3-5	21-66	-	22.9-56.1 (33.0)
110	4278_A-B_L9 (Intrusive?)	*Os coxae* (L.)	-	-	-	-	-	-	-	Cat. (2) (min.25-32)	-
110	4206_(4203_B_L4)	*Os coxae* (L.)	-	-	-	-	-	5	27-66	Cat. 3 (33-40)	31.4-104.4 (60.4)

110	4203_B_L7	*Os coxae* (L.)	4 (-7)	35-59	6	39-91	41.4-110.0 (82.1)	-	-	-	-
110	4203_B_L7 (Match? = Sacrum (4203_E_L7)	*Os coxae* (L.)	5-6	40-49	5	29-88	32.4-103.2 (66.3)	-	-	-	-
110	4203_C_L7	*Os coxae* (L.)	4-5	35-44	4	29-81	29.9-110.0 (72.9)	-	-	-	-
110	4203-4278_C-F_L8-9	*Os coxae* (L.)	5?	40-44?	-4-5+	29-88+	15.7-88.9 (44.9)	-	-	-	-
110	4203_D_L7	*Os coxae* (L.)	-	-	-	-	-	-	-	-	-
110	4203_F_L8	*Os coxae* (L.)	-	-	-	-	-	1	15-23	Cat 1 (18-24)	15.0-21.6 (15.0)
110	4180_Quad_B_Top	*Os coxae* (R.)	5 X	40-44	5	29-88	22.9-110.0 (71.2)	5	27-66	Cat. (2) (min.25-32)	33.0-110.0 (96.4)
110	4180_Quad_B_Top-L2	*Os coxae* (R.)	-	-	-	-	-	-	-	-	-
110	4203_A-C_L7	*Os coxae* (R.)	-	-	-	-	-	4-5? X	23-66?	Cat. (2)(min.25-32)	15.0-110.0 (56.4)

110	4203_C_L8	*Os coxae* (R.)	3-4	30-39	4	29-81	15.0-32.4 (18.2)	-	-	-	-
110	4203_E_L7	*Os coxae* (R.)	5-6 X	40-49 X	6 X	39-91X	19.6-107.6 (56.6)	-	-	-	-
110	4283_(4278_F_L9)	*Os coxae* (R.)	4	35-39	3?	16-65	21.9-78.1 (45.3)	-	-	-	-
110	4203_G_L8	*Os coxae* (R.)	Min.4-5	35-44	5?	29-88	62.2-110.0 (93.9)	-	-	-	-
110	4203_H_L8	*Os coxae* (R.)	-	-	-	-	-	5	27-66	Cat. 3 (33-40)	27.9-84.6 (46.7)
110	4203_H_L8_2nd	*Os coxae* (R.)	-	-	-	-	-	5	27-66	Cat. (2) (min.25-32)	27.9-110.0 (54.6)

X = broken/incomplete

N.B. For the Boldsen et al. (2002) Transition Analysis method, only the uncorrected age ranges for the specific regional characteristics (i.e. auricular surface and public symphysis) are given.

For the Dudzik and Langley method for pubic symphysis, only the implemented flow chart was used (Dudzik and Langley, 2015: 104).

Table 22: Sexing of cranial remains from burials 101 and 110.

Burial No.	Context ID	Region/ element	Overall sex category	Overall Sex	Reference	DNA	Reference
101	4147	Cranium	1-2	Male	Powers (2012)	Male	Haber et al. (2019)
101	4150	Cranium	1-2	Male	Powers (2012)		
101	4164	Cranium	1-2	Male?	Powers (2012)		
110	4301_(4180_QuadC)	Cranium	1-2	Male?	Powers (2012)	Male	Haber et al. (2019)
110	4304_(4180_QuadD)	Cranium	2-3	Male?	Powers (2012)	Male	Haber et al. (2019)
110	4203_A_L4	Cranium	2-3	Male?	Powers (2012)	Male	Haber et al. (2019)
110	4203_A-B_L5-L6	Cranium	(2)	Indeterminate	Powers (2012)		
110	4203-4278_A-C_L8-L9	Cranium	2	Male?	Powers (2012)		
110	4203_E_L7	Cranium	2-3	Male?	Powers (2012)		
110	4203_H_L5	Cranium	1-2	Male?	Powers (2012)		
110	4213	Cranium	2	Male?	Powers (2012)		
110	4234	Cranium	1-2	Male	Powers (2012)		

110	4247	Cranium				Male	Haber et al. (2019)
110	4271	Cranium	2-3	Male?	Powers (2012)	Male	Haber et al. (2019)
110	4203_E	Petrous				Male	Haber et al. (2019)
110	4278	Petrous				Male	Haber et al. (2019)

APPENDIX A6: Peri-mortem Trauma Prevalence

Table 23: Burials 101 and 110, College Site, Sidon – Peri-mortem trauma (Definite only) prevalence by body region.

Definite Only	N = 99				**Crude Prevalence (%, MNI = 25)**		
Body Region	Total No.	SFT (n)	BFT (n)	PFT (n)	SFT	BFT	PFT
Head	18	6	11	3	24.0	44.0	12.0
Neck	24	24	0	0	96.0	0.0	0.0
Shoulders	8	5	3	0	20.0	12.0	0.0
Arms/ Forearms	8	5	3	0	20.0	12.0	0.0
Hands	11	10	1	0	40.0	4.0	0.0
Torso	10	6	4	0	24.0	16.0	0.0
Hips	1	0	1	0	0.0	4.0	0.0
Thighs	11	4	6	1	16.0	24.0	4.0
Legs	6	0	5	1	0.0	20.0	4.0
Feet	2	1	1	0	4.0	4.0	0.0
Unidentified	0	0	0	0	0.0	0.0	0.0

Table 24: Burials 101 and 110, College Site, Sidon – Peri-mortem trauma (Definite + Probable only) prevalence by body region.

Definite + Probable	N = 398				**Crude Prevalence (%, MNI = 25)**		
Body Region	Total No.	SFT (n)	BFT (n)	PFT (n)	SFT	BFT	PFT
Head	56	20	38	7	80.0	152.0	28.0
Neck	31	29	2	0	116.0	8.0	0.0
Shoulders	31	16	20	4	64.0	80.0	16.0
Arms/ Forearms	54	25	31	2	100.0	124.0	8.0
Hands	55	36	14	5	144.0	56.0	20.0
Torso	36	16	18	2	64.0	72.0	8.0
Hips	15	1	13	1	4.0	52.0	4.0
Thighs	35	14	24	5	56.0	96.0	20.0
Legs	39	10	31	7	40.0	124.0	28.0
Feet	33	17	16	4	68.0	64.0	16.0
Unidentified	13	8	5	0	32.0	20.0	0.0

Table 25: Burials 101 and 110, College Site, Sidon – Peri-mortem trauma (All possibles) prevalence by body region.

Definite + Probable	N = 764				Crude Prevalence (%, MNI = 25)		
Body Region	Total No.	SFT (n)	BFT (n)	PFT (n)	SFT	BFT	PFT
Head	70	34	42	11	136.0	168.0	44.0
Neck	42	36	6	0	144.0	24.0	0.0
Shoulders	44	21	31	4	84.0	124.0	16.0
Arms/ Forearms	93	38	66	4	152.0	264.0	16.0
Hands	146	96	39	12	384.0	156.0	48.0
Torso	82	26	47	11	104.0	188.0	44.0
Hips	28	3	24	1	12.0	96.0	4.0
Thighs	45	19	37	9	76.0	148.0	36.0
Legs	68	19	50	15	76.0	200.0	60.0
Feet	114	57	51	11	228.0	204.0	44.0
Unidentified	32	22	11	0	88.0	44.0	0.0

Sharp Force Prevalence by individual element

Table 26: Burials 101 and 110, College Site, Sidon – Crude and true prevalence of sharp force trauma in the clavicle.

Clavicle	Crude Prevalence (%)		Minimum True Prevalence (%)		Maximum True Prevalence (%)	
	(L.)	(R.)	(L.)	(R.)	(L.)	(R.)
Definite SFT	8.0	0.0	10.5	0.0	10.5	0.0
Definite + Probable	8.0	8.0	10.5	10.5	10.5	11.1
All Possibles	12.0	16.0	15.8	21.1	15.8	22.2

Table 27: Burials 101 and 110, College Site, Sidon – Crude and true prevalence of sharp force trauma in the scapula.

Scapula	Crude Prevalence (%)		Minimum True Prevalence (%)		Maximum True Prevalence (%)	
	(L.)	(R.)	(L.)	(R.)	(L.)	(R.)
Definite SFT	0.0	4.0	0.0	4.2	0.0	5.0
Definite + Probable	12.0	12.0	11.1	12.5	13.6	15.0
All Possibles	12.0	50.0	11.1	20.8	13.6	25.0

Table 28: Burials 101 and 110, College Site, Sidon – Crude and true prevalence of sharp force trauma in the humerus.

Humerus	Crude Prevalence (%)		Minimum True Prevalence (%)		Maximum True Prevalence (%)	
	(L.)	(R.)	(L.)	(R.)	(L.)	(R.)
Definite SFT	8.0	8.0	9.1	9.1	10.5	10.5
Definite + Probable	28.0	26.3	31.8	22.7	36.8	20.0
All Possibles	28.0	31.6	31.8	27.3	36.8	24.0

Table 29: Burials 101 and 110, College Site, Sidon – Crude and true prevalence of sharp force trauma in the ulna.

Ulna	Crude Prevalence (%)		Minimum True Prevalence (%)		Maximum True Prevalence (%)	
	(L.)	(R.)	(L.)	(R.)	(L.)	(R.)
Definite SFT	0.0	4.0	0.0	4.3	0.0	4.5
Definite + Probable	28.0	8.0	29.2	8.7	30.4	9.1
All Possibles	36.0	20.0	37.5	21.7	39.1	22.7

Table 30: Burials 101 and 110, College Site, Sidon – Crude and true prevalence of sharp force trauma in the radius.

Radius	Crude Prevalence (%)		Minimum True Prevalence (%)		Maximum True Prevalence (%)	
	(L.)	(R.)	(L.)	(R.)	(L.)	(R.)
Definite SFT	0.0	0.0	0.0	0.0	0.0	0.0
Definite + Probable	8.0	4.0	9.5	4.2	10.5	5.6
All Possibles	12.0	20.0	14.3	20.8	15.8	27.8

Table 31: Burials 101 and 110, College Site, Sidon – Crude and true prevalence of sharp force trauma in the *Os coxae*.

Os coxae	Crude Prevalence (%)		Minimum True Prevalence (%)		Maximum True Prevalence (%)	
	(L.)	(R.)	(L.)	(R.)	(L.)	(R.)
Definite SFT	0.0	0.0	0.0	0.0	0.0	0.0
Definite + Probable	0.0	4.0	0.0	5.6	0.0	5.6
All Possibles	0.0	4.0	0.0	5.6	0.0	5.6

Table 32: Burials 101 and 110, College Site, Sidon – Crude and true prevalence of sharp force trauma in the femur.

Femur	Crude Prevalence (%)		Minimum True Prevalence (%)		Maximum True Prevalence (%)	
	(L.)	(R.)	(L.)	(R.)	(L.)	(R.)
Definite SFT	8.0	8.0	8.3	8.7	8.7	8.7
Definite + Probable	28.0	28.0	29.2	30.4	30.4	30.4
All Possibles	40.0	32.0	41.7	34.8	43.5	34.8

Table 33: Burials 101 and 110, College Site, Sidon – Crude and true prevalence of sharp force trauma in the patella.

Patella	Crude Prevalence (%)		Minimum True Prevalence (%)		Maximum True Prevalence (%)	
	(L.)	(R.)	(L.)	(R.)	(L.)	(R.)
Definite SFT	0.0	0.0	0.0	0.0	0.0	0.0
Definite + Probable	12.0	0.0	16.7	0.0	17.6	0.0
All Possibles	24.0	12.0	33.3	13.6	35.3	15.0

Table 34: Burials 101 and 110, College Site, Sidon – Crude and true prevalence of sharp force trauma in the tibia.

Tibia	Crude Prevalence (%)		Minimum True Prevalence (%)		Maximum True Prevalence (%)	
	(L.)	(R.)	(L.)	(R.)	(L.)	(R.)
Definite SFT	0.0	0.0	0.0	0.0	0.0	0.0
Definite + Probable	12.0	12.0	15.0	20.0	15.0	20.0
All Possibles	16.0	12.0	20.0	20.0	20.0	20.0

Table 35: Burials 101 and 110, College Site, Sidon – Crude and true prevalence of sharp force trauma in the fibula.

Fibula	Crude Prevalence (%)		Minimum True Prevalence (%)		Maximum True Prevalence (%)	
	(L.)	(R.)	(L.)	(R.)	(L.)	(R.)
Definite SFT	0.0	0.0	0.0	0.0	0.0	0.0
Definite + Probable	0.0	4.0	0.0	6.3	0.0	6.3
All Possibles	4.0	8.0	6.7	12.5	7.1	12.5

Table 36: Burials 101 and 110, College Site, Sidon – Crude and true prevalence of sharp force trauma in the calcaneus.

Calcaneus	Crude Prevalence (%)		Minimum True Prevalence (%)		Maximum True Prevalence (%)	
	(L.)	(R.)	(L.)	(R.)	(L.)	(R.)
Definite SFT	0.0	4.0	0.0	5.0	0.0	5.0
Definite + Probable	8.0	4.0	9.1	5.0	10.0	5.0
All Possibles	12.0	4.0	13.6	5.0	15.0	5.0

Table 37: Burials 101 and 110, College Site, Sidon – Crude and true prevalence of sharp force trauma in the talus.

Talus	Crude Prevalence (%)		Minimum True Prevalence (%)		Maximum True Prevalence (%)	
	(L.)	(R.)	(L.)	(R.)	(L.)	(R.)
Definite SFT	0.0	0.0	0.0	0.0	0.0	0.0
Definite + Probable	4.0	4.0	4.0	4.2	4.0	4.2
All Possibles	8.0	4.0	8.0	4.2	8.0	4.2

Blunt Force Trauma Prevalence by individual element

Table 38: Burials 101 and 110, College Site, Sidon – Crude and true prevalence of blunt force trauma in the clavicle.

Clavicle	Crude Prevalence (%)		Minimum True Prevalence (%)		Maximum True Prevalence (%)	
	(L.)	(R.)	(L.)	(R.)	(L.)	(R.)
Definite SFT	0.0	0.0	0.0	0.0	0.0	0.0
Definite + Probable	16.0	4.0	21.1	5.3	21.1	5.6
All Possibles	16.0	12.0	21.1	15.8	21.1	16.7

Table 39: Burials 101 and 110, College Site, Sidon – Crude and true prevalence of blunt force trauma in the scapula.

Scapula	Crude Prevalence (%)		Minimum True Prevalence (%)		Maximum True Prevalence (%)	
	(L.)	(R.)	(L.)	(R.)	(L.)	(R.)
Definite SFT	4.0	8.0	3.7	8.3	4.5	10.0
Definite + Probable	16.0	36.0	14.8	37.5	18.2	45.0
All Possibles	24.0	60.0	22.2	62.5	27.3	75.0

Table 40: Burials 101 and 110, College Site, Sidon – Crude and true prevalence of blunt force trauma in the humerus.

Humerus	Crude Prevalence (%)		Minimum True Prevalence (%)		Maximum True Prevalence (%)	
	(L.)	(R.)	(L.)	(R.)	(L.)	(R.)
Definite SFT	0.0	4.0	0.0	4.5	0.0	5.3
Definite + Probable	16.0	28.0	18.2	31.8	21.1	36.8
All Possibles	44.0	44.0	50.0	50.0	57.9	57.9

Table 41: Burials 101 and 110, College Site, Sidon – Crude and true prevalence of blunt force trauma in the ulna.

Ulna	Crude Prevalence (%)		Minimum True Prevalence (%)		Maximum True Prevalence (%)	
	(L.)	(R.)	(L.)	(R.)	(L.)	(R.)
Definite SFT	0.0	4.0	0.0	4.3	0.0	4.5
Definite + Probable	16.0	16.0	16.7	17.4	17.4	18.2
All Possibles	44.0	36.0	45.8	39.1	47.8	40.9

Table 42: Burials 101 and 110, College Site, Sidon – Crude and true prevalence of blunt force trauma in the radius.

Radius	**Crude Prevalence (%)**		**Minimum True Prevalence (%)**		**Maximum True Prevalence (%)**	
	(L.)	**(R.)**	**(L.)**	**(R.)**	**(L.)**	**(R.)**
Definite SFT	0.0	4.0	0.0	4.2	0.0	5.6
Definite + Probable	24.0	16.0	28.6	16.7	31.6	22.2
All Possibles	56.0	32.0	66.7	33.3	73.7	44.4

Table 43: Burials 101 and 110, College Site, Sidon – Crude and true prevalence of blunt force trauma in the *Os coxae*.

Os coxae	**Crude Prevalence (%)**		**Minimum True Prevalence (%)**		**Maximum True Prevalence (%)**	
	(L.)	**(R.)**	**(L.)**	**(R.)**	**(L.)**	**(R.)**
Definite SFT	4.0	0.0	4.2	0.0	4.2	0.0
Definite + Probable	28.0	20.0	29.2	27.8	29.2	27.8
All Possibles	44.0	32.0	45.8	44.4	45.8	44.4

Table 44: Burials 101 and 110, College Site, Sidon – Crude and true prevalence of blunt force trauma in the femur.

Femur	**Crude Prevalence (%)**		**Minimum True Prevalence (%)**		**Maximum True Prevalence (%)**	
	(L.)	**(R.)**	**(L.)**	**(R.)**	**(L.)**	**(R.)**
Definite SFT	12.0	12.0	12.5	13.0	13.0	13.0
Definite + Probable	40.0	48.0	41.7	52.2	43.5	52.2
All Possibles	64.0	80.0	66.7	87.0	69.6	87.0

Table 45: Burials 101 and 110, College Site, Sidon – Crude and true prevalence of blunt force trauma in the patella.

Patella	**Crude Prevalence (%)**		**Minimum True Prevalence (%)**		**Maximum True Prevalence (%)**	
	(L.)	**(R.)**	**(L.)**	**(R.)**	**(L.)**	**(R.)**
Definite SFT	0.0	4.0	0.0	4.5	0.0	5.0
Definite + Probable	8.0	12.0	11.1	13.6	11.8	15.0
All Possibles	12.0	16.0	16.7	18.2	17.6	20.0

Table 46: Burials 101 and 110, College Site, Sidon – Crude and true prevalence of blunt force trauma in the tibia.

Tibia	**Crude Prevalence (%)**		**Minimum True Prevalence (%)**		**Maximum True Prevalence (%)**	
	(L.)	**(R.)**	**(L.)**	**(R.)**	**(L.)**	**(R.)**
Definite SFT	12.0	4.0	15.0	6.7	15.0	6.7
Definite + Probable	40.0	28.0	50.0	46.7	50.0	46.7
All Possibles	44.0	40.0	55.0	66.7	55.0	66.7

Table 47: Burials 101 and 110, College Site, Sidon – Crude and true prevalence of blunt force trauma in the fibula.

Fibula	Crude Prevalence (%)		Minimum True Prevalence (%)		Maximum True Prevalence (%)	
	(L.)	(R.)	(L.)	(R.)	(L.)	(R.)
Definite SFT	0.0	0.0	0.0	0.0	0.0	0.0
Definite + Probable	12.0	20.0	20.0	31.3	21.4	31.3
All Possibles	44.0	28.0	73.3	43.8	78.6	43.8

Table 48: Burials 101 and 110, College Site, Sidon – Crude and true prevalence of blunt force trauma in the calcaneus.

Calcaneus	Crude Prevalence (%)		Minimum True Prevalence (%)		Maximum True Prevalence (%)	
	(L.)	(R.)	(L.)	(R.)	(L.)	(R.)
Definite SFT	0.0	4.0	0.0	5.0	0.0	5.0
Definite + Probable	8.0	20.0	9.1	25.0	10.0	25.0
All Possibles	24.0	32.0	27.3	40.0	30.0	40.0

Table 49: Burials 101 and 110, College Site, Sidon – Crude and true prevalence of blunt force trauma in the talus.

Talus	Crude Prevalence (%)		Minimum True Prevalence (%)		Maximum True Prevalence (%)	
	(L.)	(R.)	(L.)	(R.)	(L.)	(R.)
Definite SFT	0.0	0.0	0.0	0.0	0.0	0.0
Definite + Probable	4.0	4.0	4.0	4.2	4.0	4.2
All Possibles	28.0	12.0	28.0	12.5	28.0	12.5

APPENDIX A7: Peri-mortem Trauma (Definite) Descriptions

Table 50: Burials 101 and 110, College Site, Sidon - Context and element details for human remains exhibiting peri-mortem trauma.

No.	Age	PFT?	BFT?	SFT?	Burial No.	Context	Bone Element
1	Subadult		BFT?	SFT	101	4156_ArmB	Humerus (L.)
2				SFT	101	4168_ArmF	Hamate (R.)
3				SFT	101	4168_ArmF	Triquetral (R.)
4				SFT	101	4168_ArmF	Pisiform? (R?)
5				SFT	101	4168_ArmF	MC3 (R.)
6			BFT		101	4169_LegG	*Os coxae* (L.)
7				SFT	101	4169_LegG	Femur (L.)
8	YA?		BFT?	SFT	101	4171_LegH	Femur (R.)
9	YA	PFT/SFT	BFT; BFT?		101	4172_LegI	Femur (L.)
10				SFT	101	4147_TorsoC	Cervical vertebra (C3)
11				SFT	101	4147_TorsoC	Cervical vertebra (C4)
12				SFT?	101	4147_TorsoC	Thoracic vertebra (T09)
13				SFT	110	4180_QuadB	Cervical vertebra (C2)
14				SFT/BFT?	110	4180_QuadB	Cervical vertebra
15				SFT	110	4180_QuadB	Clavicle (L.)
16				SFT	110	4180_QuadB_L2	Cervical vertebra
17			BFT/SFT? x min.1		110	4180_QuadD	Scapula (L.)
18				SFT/BFT x min.1	110	4180_QuadD	Scapula (R.)
19		PFT/SFT(Stab)?	BFT		110	4180_QuadE	Scapula (R.)
20				SFT	110	4201_EFGH_L1	Cervical vertebra
21				SFT?	110	4201_H_(2010)	Cervical vertebra

22				SFT	110	4203_A_L5	Clavicle (L.)
23			BFT?	SFT	110	4203_A_L5	Humerus (R.)
24			BFT?		110	4203_A_L6	Lunate (L.)
25			BFT		110	4203_A_L6	Tibia (L.)
26		PFT/SFT			110	4203_A_L6	Tibia (L.)
27				SFT?	110	4203_B_L7	Humerus (L.)
28			BFT? (Min. 1)		110	4203_D_L5	Calcaneus (R.)
29				SFT x min.1-2	110	4203_D_L6	Cervical vertebra
30			BFT?		110	4203_D_L6	Rib (U.)
31				SFT?	110	4219_(4203_E_L5)	Hamate (R.)
32		PFT/BFT?	BFT; BFT? x min.3; BFT/SFT		110	4203_E_L6	Femur (R.)
33			BFT; BFT?		110	4203_E_L6	Rib (L.)
34				SFT?	110	4203_E_L6	Rib (U.)
35			BFT x min.2; BFT/SFT?;		110	4203_E_L7	Femur (R.)
36				SFT	110	4270_(4203_E_L8)	MC3 (R.)
37				SFT	110	4203_F_L7	Cervical vertebra
38			BFT x min.1	SFT/BFT?	110	4203_F_L7-L8	Scapula (R.)
39				SFT	110	4203_G_L7	Cervical vertebra
40				SFT	110	4203_G_L7	Intermediate Hand phalanx
41				SFT/BFT	110	4203_H_L5	thoracic vertebra
42			BFT		110	4210_(4203_C-D_L5)	Patella (R.)
43			BFT		110	4217_(4203_E_L5)	Radius (R.)
44		PFT/SFT(Stab)?	BFT; BFT/SFT?		110	4239_(4203_B_L7)	Femur (R.)
45			BFT; BFT?		110	4253_(4203_E_L7)	Tibia (R.)
46			BFT x 2	SFT/BFT?	110	4274_(4203_F_L8)	Humerus (R.)

47			BFT; BFT? x min.2		110	4275_(4203_D-F_L8)	Tibia (L.)
48				SFT	110	4278_A-C_L9	Proximal Hand phalanx
49				SFT	110	4278_A-C_L9	Proximal Hand phalanx
50				SFT?	110	4278_B?_L9	Calcaneus (R.)
51				SFT?	110	4278_B_L9	Cervical vertebra (C1)
52				SFT?	110	4278_C_L10	Cervical vertebra
53			BFT? x min.1	SFT	110	4278_F_L9	Femur (L.)
54				SFT	110	4278_F_L9	Distal Hand phalanx
55				SFT?	110	4278_H_L10	Femur (R.)
56			BFT; BFT?		110	4284_(4278_F-D_L9)	Femur (L.)
57			BFT		110	4284_(4278_F-D_L9)	Tibia (L.)
58			BFT; BFT?		110	4292_(4278_C_L9)	Ulna (R.)
59	Subadult	PFT/BFT?	BFT x min.1; BFT? x min.3-4	SFT?	110	4293_(4278_D-F_L10)	Femur (L.)
60				SFT?	110	4305_(4180_QuadD)	Ulna (R.)
61		Projectile or PFT/BFT; PFT/SFT(Stab)? x min. 1			110	4311_(4180_QuadD_L2_L.Femur _artic)	Femur (L.)
62				SFT	110	4203_B_L6_(SEcorner)	Mandible (L.)
63				SFT x min.1-2	110	4247_(4278_B_L9)	Cervical vertebra (C3)
64				SFT	110	4247_(4278_B_L9)	Cervical vertebra (C4)
65				SFT x min.2-3	110	4247_(4278_B_L9)	Cervical vertebra (C5)
66				SFT x min.3	110	4247_(4278_B_L9)	Cervical vertebra (C6)
67				SFT	110	4247_(4278_B_L9)	Cervical vertebra (C7)
68			BFT		110	4247_(4278_B_L9)	Thoracic vertebra (T03)
69				SFT	110	4247_(4278_B_L9)	Cervical vertebra (C3 or C4?)

70				SFT	110	4213_(4203_A_L7)	Cervical vertebra (C4)
71				SFT x min.2	110	4304_(4180_QuadD)	Cervical vertebra (C4)
72				SFT x min.1	110	4304_(4180_QuadD)	Cervical vertebra (C5)
73				SFT x min.1	110	4271_(4203_G_L5-L6)	Cervical vertebra (C5)
74			BFT; BFT or PFT	SFT?	101	4147_TorsoC	Cranium
75			BFT		101	4147_TorsoC	Mandible (R.)
76		PFT?	BFT X min.2;		101	4150_SkullA	Cranium
77			BFT-multiple?	SFT?	101	4164_SkullB	Cranium
78			BFT; BFT? X min.2	SFT	110	4301_(4180_QuadC)	Cranium
79		PFT x min.1;	BFT x min.2		110	4304_(4180_QuadD)	Cranium
80			BFT x min.1-2;		110	4213_A_L7	Cranium
81		PFT?	BFT/SFT; BFT x min.1	SFT?	110	4271_(4203_G_L5-L6)	Cranium
82			BFT x min.1		110	4203_F_L8	Cranium
83		PFT or BFT	BFT x min.2		110	4203_A-C_L8-9	Cranium
84		PFT? x 4?	BFT x 3;	SFT x 2	110	4247_(4203-4278_B_L6-9)	Cranium
85			BFT		110	4203_G_L6	Mandible (R.)
86		PFT/BFT or BFT		SFT/BFT?	110	4234_(4203_H_L8)	Mandible (L.)
87			BFT x min.1-2	SFT x 2	110	4180_QuadB	Mandible (R.)
88				SFT	110	4203_B_L6_(SEcorner)	Mandible (R.)
89			BFT or BFT/PFT; BFT?		110	4203_B_L6_(SEcorner)	Mandible (L.)
90				SFT	110	4278_A_L9	Mandible (R.)
91				SFT x min.1	101	4150_SkullA	Cervical vertebra (C2)
92				SFT x min.1	110	4180_QuadD	Cervical vertebra (C3-C7)
93				SFT	110	4259_(4203_E_L7)	Lumbar vertebra (L1/L2?)
94				SFT	110	4259_(4203_E_L7)	Lumbar vertebra (L2/L3?)

95				**SFT**	110	4259_(4203_E_L7)	Lumbar vertebra (L3/L4?)
96				**SFT**	110	4246_(4203-4278_A-B_L6-L9)	Clavicle (R.)
97			**BFT?**	**SFT x min.2**	110	4246_(4203-4278_A-B_L6-L9)	Scapula (R.)
98				**SFT**	110	4246_(4203-4278_A-B_L6-L9)	Humerus (R.)
99			**BFT?**		101	4151_TorsoB	Rib (L.)

= Definite **= Probable** **= Possible**

Table 51: Burials 101 and 110, College Site, Sidon – Written descriptionsfor human remains exhibiting peri-mortem trauma.

No.	Context	Description
1	4156_ArmB	**1)** Complete irregular, transverse fracture to midshaft of L. Humerus, stained, slight evidence of burning - **Possible peri-mortem BFT?** **2)** Small, thin, linear incision (max. 4.8 x ~0.5mm wide) penetrating deep into inferior aspect of capitulum of L. Humerus - **Probable peri-mortem SFT(Stab)**. Septal aperture - nice large example. Maximum bicondylar width = 55.2mm.
2	4168_ArmF	Extant fragment indicates large size. **1)** Complete fracture across body of R. Hamate, with loss of distal dorsal section of body, fracture surface relatively stained, corresponds reasonably well with fractured/cut surfaces of R. Triquetral and R. Pisiform - **Probable peri-mortem SFT(/BFT), likely associated also with probable SFT to dorsal aspect of proximal R. MC3 - i.e. a single defensive wound?**
3	4168_ArmF	**1)** Complete transverse fracture with loss of distal 1/3, forming v. flat fracture surface, relatively stained, corresponds well with fractured/cut surface of R. Pisiform and reasonably well with that of R. Hamate - **Probable peri-mortem SFT(/BFT), likely associated also with probable SFT to dorsal aspect of proximal R. MC3 - i.e. a single defensive wound?**
4	4168_ArmF	**1)** Complete transverse fracture with loss of distal 2/3, forming v. flat fracture surface, relatively stained, corresponds well with fractured/cut surface of R. Triquetral and reasonably well with that of R. Hamate - **Probable peri-mortem SFT(/BFT), likely associated also with probable SFT to dorsal aspect of proximal R. MC3 - i.e. a single defensive wound? Id reasonably certain.**
5	4168_ArmF	**1)** Distinct v-shaped (profile) notch (max. 8.2 x 2.6mm) to medial dorsal aspect of proximal end of R. MC3 - **Probable peri-mortem SFT, likely associated with fractured/cut surfaces of R. Triquetral, R.Pisiform and R. Hamate - indicating blow was angled across back of R. wrist.**
6	4169_LegG	See photos

7	4169_LegG	See Photos Femoral head diameter = 52.2mm (standard), Max. = 52.4mm
8	4171_LegH	See Photos Younger Adult? - Epiphyseal line still slightly evident in femoral head. Femoral head diameter (fractured with loss, extant) (min.) = ~46.5mm
9	4172_LegI	Younger Adult - epiphyseal lines still very evident, esp. distal, although both seem fused. **1)** Incomplete, sub?-trochanteric fracture (infraction), with butterfly wedge evident, involves inferior-most aspect of lesser trochanter – **Definite peri-mortem BFT.** **2)** Penetrating lesion to medial aspect of distal epiphysis, with possible evidence of linear SFT (stab?) within slightly cavitated lesion - **Possible/probable peri-mortem PFT/SFT(Stab)? Alternatively post-mortem breakage due to scavenging?** **3)** Large crush fracture to posterior medial surface of distal medial condyle - **Possible peri-mortem BFT from shaped object? Alternatively blunt-edged weapon trauma or crushing in situ?** Femoral head diameter (fractured with loss, extant) (min.) = ~42.6mm.
10	4147_TorsoC	See Case study 2.
11	4147_TorsoC	See case study 2.
12	4147_TorsoC	See Case Study 2.
13	4180_QuadB	**1)** Consistent oblique fracture, with v. consistent, v. flat-looking, almost polished in places, stained fracture surfaces to extant body and R. neural arch lamina, most likely descending from L. side to R. side, through inferior vertebral body of C2 and R. neural arch lamina, with loss of almost all L. superior apophyseal facet - **Definite peri-mortem SFT (probable downward blow from high on L. side).**
14	4180_QuadB	**1)** Extant inferior portion of spinous process exhibits consistent, v. flat-looking fracture surface to superior aspect, with slight evidence of crushing/depression to laminae and v. small radiating fractures, some slight evidence of burning/charring evident - **Possible/probable peri-mortem SFT/BFT?**

15	4180_QuadB	**1)** Fracturing with loss of section of bone to superior anterior aspect of medial end of L. Clavicle, with very consistent and v. flat, oblique, smooth and stained fracture surface, some polished cortical also - **Definite peri-mortem SFT.**
16	4180_QuadB_L2	Unburnt? **1)** Extant cervical vertebra exhibits v. consistent fracture outline across superior L. Apophysis and vertebral body, with fracturing/loss of superior L. Apophyseal facet and L. uncinate process of body, forming v. consistent, v. flat (almost polished), smooth, stained fracture surface, with v. slight clipping/smoothing evident also to R. uncinate process and superior margin of R. Apophyseal facet - **Definite peri-mortem SFT (probable blow from L. side, but not certain - suggests head would have to have been leant to R. side, unless swing was upwards slightly)**. Unusual morphology to spinous process. Found articulated with 1 inferior cervical vertebra (latter unaffected by any evident trauma).
17	4180_QuadD	**1)** Complete irregular oblique linear-looking fracture across middle of L. Acromion, with stained irregular fracture surface, associated incomplete fracture to inferior surface of lateral Acromion & associated missing section of bone to posterior Acromion - **Probable/Definite peri-mortem BFT/SFT?** **2)** Area of substantial fracturing with loss to superior border of L. Scapula, with associated incomplete radiating fracture esp. evident to superior surface of L. Acromial root/spine and associated complete fracture across base of Acromial spine, majority of fracture surfaces appear old/stained - **Probable peri-mortem BFT, possibly associated with probable/definite peri-mortem BFT to L. Acromion itself?**

18	4180_QuadD	Only medial aspect of R. Acromion (inc. lateral root and medial portion of acromial wing) present, lateral portion fractured, missing. **1)** Cut surface to lateral posterior aspect of lateral root of acromial spine, with polished-smooth fracture surface, with sharp margins - shave defect - **Definite peri-mortem SFT.** **2)** Base of lateral root of acromial spine also exhibits siginificant thin spall and consistent, quite flat-looking fracture surface - **Probable peri-mortem BFT associated with definite SFT to region above?** **3)** Posterior margin of inferior surface of extant lateral wing exhibits defined area of linear fracturing, with quite smooth, stained fracture surface, (there is also overlying recent post-mortem breakage to lateral broken end) - **Possible peri-mortem SFT/BFT, again likely associated with definite peri-mortem SFT to region?**
19	4180_QuadE	**1)** Penetrating lesion to medial inferior surface of R. Coracoid process, associated with complete fracture to coracoid process with v. flat medial fracture surface, corresponds well with v. slight area of fracturing and loss to superior posterior margin of R. Glenoid cavity - **Probable peri-mortem PFT/SFT(Stab)?** **2)** Unusual irregular fracture surface to base of acromial spine, suggesting bevelling/spalling with smooth fracture surfaces - **Probable peri-mortem BFT?**
20	4201_EFGH_L1	**1)** Extant inferior portion of cervical spinous process exhibits fracturing with loss of superior lamina, forming v. consistent, v. flat, smooth, stained fracture surface - **Definite peri-mortem SFT.**
21	4201_H_(2010)	Cremated. **1)** Extant inferior cervical L. Apophysis exhibits consistent, v. flat, stained transverse fracture surface superiorly - **Probable/definite peri-mortem SFT (horizontal transverse blow to side of neck?).**
22	4203_A_L5	Partially cremated at least, heat-line. Medial end of extant L. Clavicle fractured, missing. **1)** Fracturing and loss to inferior surface of lateral end, forming v. consistent, v.flat stained fractuure surface - **Definite peri-mortem SFT.**
23	4203_A_L5	Extant fragment of proximal R. Humerus suggests Large size. **1)** Fracture surface vertical, consistent and flat across fracture margins, with stained fracture surface - **Probable/definite peri-mortem SFT/BFT?** **2)** There is also a small area of fracturing/depression (max. 7.1 x 5.4mm) to the inferior lateral surface of the Gt. Tubercle - **Possible peri-mortem BFT or PFT/BFT?** **3)** Possible antemortem large open (healed?) subchondral cyst (max. 5.4 x 4.7mm) to anterior Gt. trochanter? Alternatively natural morphology?

24	4203_A_L6	Unburnt?/V.Slightly sooted? **1)** Incomplete fracture to proximal aspect of radial articular surface, with displaced/hinged/retained portion of articular surface in situ - **Probable/Definite peri-mortem BFT** to L. Wrist?
25	4203_A_L6	Burnt/Partially blackened (heat-line); Incomplete, majority of proximal end, tibial tuberosity fractured, missing; Some fracturing with loss to medial anterior aspect and posterior margins of tibial condyles; **1)** Distinct depression/impression (c.19.0xc.6.8mm, narrows towards floor of depression) to posterior lateral aspect of tibial head, just anterior and superior to proximal fibular articular surface, with associated incomplete radiating fracture, displaced/hinged/retained section of bone and possible associated plastic deformation(?) - **Probable peri-mortem BFT to outside of L. Knee?**
26	4203_A_L6	Cremated (white/grey/dark grey) (heat-line); Incomplete, majority of distal end only, majority of medial malleolus fractured, missing; **1)** Small, penetrating lesion (c.3.9xc.3.4mm) to posterior medial aspect just above medial malleolus, with linear fracture within lesion along with depressed/retained fragments of cortical surface, possible plastic deformation and associated incomplete radiating fractures - **Definite peri-mortem PFT/SFT/Stab wound to (posterior?) inside of L. ankle?** Lateral Squatting facet present
27	4203_B_L7	Partially cremated, heat-line. **1)** Small, horizontal linear 'nick' (max. 4.4mm (medio-laterally) x max. 1.2mm wide (proximo-distally) to anterior aspect of distal diaphysis of extant L. Humerus - **Possible peri-mortem SFT? Alternatively fracture related to thermal alteration, but seems odd to be a single, isolated one of these?**

28	4203_D_L5	Unburnt?/V.Slightly sooted?; Incomplete, some fracturing with loss to lateral aspect of posterior calcaneal body; **1)** Large area of depression (c.32xc.21.2mm) to lateral aspect of posterior calcaneal body, with associated incomplete fractures and depressed/hinged/retained fragments of cortical surface; **2)** There is also a smaller, more-defined depression (c.6xc.4.2mm) to inferior lateral aspect of calcaneal body, just anterior to main, large area of depression - **Definite peri-mortem BFT to outside of R. Heel.** (see also R. Cuboid fragment from same grid/layer/bag - possible 2nd peri-mortem BFT blow to anterior R. Foot (if belonging to same individual - extant articulation seems potential match); Split/double articular surface of sustentaculum tali with 2 completely separate articular surfaces for anterior talar articulation --> non-metric trait; Maximum length (some fracturing, minimum) = 80.2mm
29	4203_D_L6	Cremated (grey/dark grey/brown/white). Incomplete, posterior aspect of spinous process only. **1)** V. flat fracture surface, with polish evident to adjacent cortical bone - **Definite peri-mortem SFT to (posterior?) L. side of neck?** **2) Possibly 2 cuts?** Another possible polished surface slightly posterior and lateral to one first described; Id not certain
30	4203_D_L6	Unburnt; Incomplete, rib head only, costal facet fractured, missing. **1)** Area of depresssion evident to ventral surface of distal broken end of extant fragment, with incomplete fractures & depressed/hinged/retained cortical surface - **Probable peri-mortem BFT to mid-spine region**. Siding not totally certain, id not certain - probably mid-chest region?
31	4219_(4203_E_L5)	Unburnt; Incomplete, palmar half only; V. Large; **1)** V. straight, flat-looking fracture surface across body **- Probable peri-mortem SFT cut?**

32	4203_E_L6	**1)** Complete, oblique/spiral, trochanteric fracture to proximal diaphysis of R. Femur, transects inferior aspect of Lesser trochanter, with small incomplete radiating fracture forming partial 'butterfly'/wedge which is attached to proximal end - **Definite peri-mortem BFT.** **2)** Area of defined crushing/depression across extant Gt. Trochanter, forming v. flat, obliquely angled crushed cortical surface, with several small radiating fractures at margins of flattened area - **Probable peri-mortem BFT, possibly associated with complete fracture involving Lesser trochanter.** **3)** Small, irregular shallow depression (max.14.6 x 13.4mm) to posterior margin of R. Femoral head - Possible peri-mortem BFT? Small area of fracturing with loss & depressed/hinged/retained fragment of cortical articular surface to anterior margin of R. Femoral head - Possible peri-mortem BFT? Small area of fracturing with loss (max.7.7 x 4.2mm) lying across lateral margin of anterior lateral condylar articular surface, looks old - **Possible peri-mortem trauma - PFT/BFT? Not certain.** Just posterior to this, there is some additional slight fracturing with loss and slight crushing/depression extending along the lateral margin. **4)** There is also a small defined area of crushing/depression, with a linear anterior edge to medial aspect of the posterior medial condyle (max. 10.2mm (linear edge) x 7.9mm) - **Probable peri-mortem edged BFT/SFT?** Femoral head diameter (fractured, with some loss) = min.~48.5mm. Maximum bicondylar width (using sliding calipers) = 83.7mm. Unusually pronounced tubercle/process to superior posterior aspect of medial condyle - similar to those observed in other femora.
33	4203_E_L6	Burnt?/V.Slightly sooted; Incomplete, segment of sternal shaft only (2 fitted fragments present). **1)** Linear fracture to exterior surface, with inflected margins, incomplete parallel (concentric?) fractures and depressed/hinged/retained fragments - **Definite peri-mortem linear BFT to L. Chest region?** **2)** Broken proximal end of proximal fragment also exhibits stained fracture surface - **Possible peri-mortem BFT to L. Chest region, potentially associated with linear BFT to same rib?**

34	4203_E_L6	Unburnt?; Incomplete, proximal articular surface and 1/2 of rib head only. **1)** Exhibits v. linear fracture outline & v. flat-looking fracture surface - **Definite peri-mortem SFT adjacent to one side of mid(?)-spine region?**
35	4203_E_L7	**1)** Small, reasonably well-defined area of depression (8.9 x 7.5mm), with one possible linear edge(?) to anterior superior R. Femoral head - **Possible peri-mortem BFT?** **2)** Femoral head is completely separated by fracture across femoral neck, which exhibits an associated small, incomplete radiating fracture across anterior Gt. trochanter - **Probable peri-mortem BFT, possibly related to crushing/fracturing to posterior proximal diaphysis?** **3)** Large area of crushing/depression to posterior aspect of extant proximal diaphysis, focussed on region of posterior aspects of Gt. and Lesser trochanters, with large fragments of cortical hinged/retained as well as loss of considerable amounts of cortical surface, possibly related to complete fracture of femoral head & associated incomplete radiating fracture? - Probable peri-mortem BFT. 4**)** Fracturing with loss to lateral anterior aspect of distal metaphysis of R. Femur, forming a deep penetrating lesion, with associated plastic deformation of adjacent cortical surface and small radiating fractures. Posterior aspect of distal metaphysis exhibits large area of at least 2 large inflected, depressed/hinged/retained cortical surface fragments, with associated incomplete radiating fractures - **Probable peri-mortem BFT, probably associated with loss of bone/plastic deformation to anterior metaphysis.** Femoral head diameter (fractured, with some loss) = min.~50.9mm.
36	4270_(4203_E_L8)	Unburnt; **1)** V. Flat-looking fracture surface to lateral dorsal aspect of proximal end, with possible 'polish' **- Probable peri-mortem SFT cut!!!**

37	4203_F_L7	Cremated. **1)** Extant cervical vertebral body exhibits consistent near horizontal transverse fracture outline across posterior superior aspect, slightly obliquely oriented medio-laterally descending slightly from R. side to L. side and obliquely angled ascending from posterior to superior, transecting R. uncinate process, with polished surface to posterior cortical - **Definite peri-mortem SFT (blow likely from behind with head angled forward/down?).**
38	4203_F_L7-L8	**N.B.** Fitted R. Glenoid cavity recovered from Layer 8. **1)** Lateral tip of R. Coracoid process of extant R. Scapula is fractured, missing, with relatively linear, stained fracture surface - **Possible peri-mortem SFT/BFT?** **2)** There is evidence of fracturing with plastic deformation to region of R. Scapular neck, with majority of associated fracture surfaces stained - **Probable peri-mortem BFT.** **3)** There is also fracturing with loss to central area of scapular blade, with extant fracture surfaces exhibiting bevelling suggesting a blow from behind (i.e. dorsal through to anterior blade) - **Possible peri-mortem BFT?** R. Glenoid cavity maximum height (fractured with slight loss) = min.~42.0mm. R. Glenoid cavity maximum width (fractured with slight loss) = min.~28.5mm.
39	4203_G_L7	**1)** Extant cervical R. Apophysis exhibits horizontal transverse fracture outline to superior aspect of superior R. Apophyseal gfacet, with consistent, v. flat (almost polished), stained fracture surface - **Definite peri-mortem SFT.**
40	4203_G_L7	See photos. Burnt/partially blackened; id reasonably certain, siding not certain.

41	4203_H_L5	**1)** R. Transverse process of mid-upper thoracic vertebra exhibits fracturing with loss to superior aspect, forming v. consistent and v. flat, stained fracture surface, associated with fractured superior R. and central lamina of neural arch and contiguous incomplete radiating fracture to superior L. lamina (most evident on ventral/anterior surface) - **Definite peri-mortem SFT/BFT.** The upper 1/2 of the vertebral body is also fractured and missing, but it is uncertain whether this loss relates to the same injury as the SFT cut to the R. Transverse process.
42	4210_(4203_C-D_L5)	**1)** Depression fracture to inferior articular surface of R. Patella (max. ~18.6 x ~16.7mm), with concentric fractures surrounding area of depressed/hinged/retained cortical articuar surface - **Definite peri-mortem BFT.** Slight entheses evident to anterior surface of R. Patella. Marked OP to lateral margin of articular surface.
43	4217_(4203_E_L5)	There is a small, well-defined area of fracturing with loss to the posterior aspect of the R. Radial head of the R. Radius (difficult to say how old it is). There is evidence of an incomplete fracture to the lateral posterior aspect of the midshaft of the diaphysis, associated with eroded cortical surface. **1)** Small area of fracturing with loss to lateral aspect of distal end of R. Radius, with associated incomplete radiating fracture and depressed anterior metaphyseal cortical surface/plastic deformation - **Probable peri-mortem BFT? Alternatively crushing in situ?** **2)** There is also an area of depression to the posterior aspect of the distal R. Radius, with depressed/hinged/retained cortical surface - **Possible peri-mortem BFT, most likely associated with the anterior depression? Alternatively crushing in situ?** Maximum length (fractured/deformed) = max. ~237mm.

44	4239_(4203_B_L7)	**1)** Large, well-defined, sub-rectilinear depression (max.32.5 x 12.6mm) to posterior aspect of medial epicondyle - **Probable peri-mortem BFT.** **2)** Heavy fracturing with loss to the lateral aspect of the distal femoral epiphysis - **Possible peri-mortem BFT/SFT?** **3)** There is also a deeper, slightly better defined, irregular, penetrating lesion (max.15 x 8mm) within this area of fracturing/loss - **Possible peri-mortem PFT/SFT(stab)?** Maximum bicondylar width (fractured, with loss) = min.~82.7mm. Unusually pronounced tubercle/process to superior posterior aspect of medial condyle - similar to those observed in other femora.
45	4253_(4203_E_L7)	**1)** Large, reasonably well-defined, sub-rectilinear depression/area of crushing to medial aspect of distal diaphysis of R. Tibia, appears to have well-defined superior edge which possibly extends linearly towards anterior, with slightly concave wall/floor, with incomplete radiating fractures towards posterior surface & across posterior talocrural surface - **Probable peri-mortem BFT.** **2)** Second small, linear-edged depression fracture to lateral aspect of distal diaphysis of R. Tibia - **Probable peri-mortem edged BFT? (Corresponds reasonably with area of fracturing with loss to lateral aspect of distal diaphysis of R. Fibula).** **3)** Marked OP/remodelled discontinuity to medial anterior margin of talocrural articular surface. Alternatively antemortem healed trauma - **Possible healed SFT/BFT? No measurements.**

46	4274_(4203_F_L8)	**1)** Large area of well-defined (almost triangular?) depression/crushing (max. 29.5 x 20.9mm) to anterior margin of R. Humeral head - **Probable peri-mortem BFT? Alternatively crushing *in situ*?** **2)** There is a second, smaller, well-defined area (max.17.2 x 12.4mm) of crushing/depression to the lateral posterior aspect of the Gt. trochanter, with depressed/hinged/retained fragments of cortical - **Probable peri-mortem BFT?** **3)** There is also evidence of marked osteophytic new bone and irregular remodelled bone around the margins of the humeral head, infilling of the bicipital groove & some macropporosity evident - **Possible/probable antemortem rotator cuff syndrome (RCS)?** **4)** Linear area of fracturing & loss across distal metaphysis, proceeding inwards from lateral epicondyle which is missing a section, with extant portion exhibiting a v. flat fracture surface. Line of fracturing and loss proceeds slightly obliquely proximally towards medial metaphysis, but stops either above medial limit of capitulum or at medial margin of anterior septal arch (max. length = 41.0mm), with trochlea/distal metapphysis also having suffered comminuted fracturing, probably subsequent to main linear fracture/cut - **Probable peri-mortem heavy SFT/BFT to lateral side of R. Elbow.** **5)** There is also a v. small, well-defined (oval?) area (max. 4.8 x 2.3mm) of depression to the inferior aspect of the capitulum, which appears to have penetrated the articular cortical surface at its posterior limit, although the latter is most likely post-mortem breakage - **Possible peri-mortem BFT? Alternatively possible osteochondritis dissecans-type lesion (seems unlikely though...).** R. Humeral head diameter (marked OP, possible RCS) = max. 49.8mm.
47	4275_(4203_D-F_L8)	**1)** Extant Proximal head of L. Tibia exhibits substantial fracturing with some loss. Anterior lateral aspect exhibits large, depressed section of cortical surface and another depressed/slightly depressed fragment of anterior intercondylar prominence. There is a somewhat linear-looking, loosely defined area of depression (max. ~17.3mm long x 6.8mm wide), angled obliquely descending from medial to lateral, with fracturing and loss to the posterior lateral aspect of the L. Tibial head, associated with this is depression/displacement (plastic deformation?) of the lateral 2/3 of the posterior metaphysis, with incomplete, radiating fracture proceeding anteriorly & medially across posterior intercondylar prominence - **Probable peri-mortem BFT (massive blow).** **2)** There is a second, slightly wider area (max. ~26mm long x ~8.4mm wide) of linear depression/crushing to the posterior aspect of the medial head, angled obliquely descending from lateral to medial - **Possible peri-mortem BFT (shaped?)**

48	4278_A-C_L9	Slightly burnt; id and siding not certain; **1)** V. Linear, oblique fracture, with v. flat-looking fracture surface - **Probable peri-mortem SFT cut, associated with at least 1 other proximal hand phalanx exhibiting v. similar fracture with almost identical fracture characteristics/alignment**;
49	4278_A-C_L9	Slightly sooted; id and siding not certain; **1)** V. Linear, oblique fracture, with v. flat-looking fracture surface - **Probable peri-mortem SFT cut, associated with at least 1 other proximal hand phalanx exhibiting v. similar fracture with almost identical fracture characteristics/alignment;**
50	4278_B?_L9	**1)** Very linear fracture to inferior aspect of calcaneal tubercle (heel), resulting in very flat fracture margin across tubercle; burnt/blackened - **Possible/probable peri-mortem SFT?**
51	4278_B_L9	Cremated. **1)** Extant L. Apophysis of C1 vertebra exhibits v.consistent and v. flat fracture surface, with superior apophyseal facet fractured/transected, missing - **Probable peri-mortem SFT. Difficult to infer direction, but probably slightly oblique cut to posterior of at least L. side of neck?**
52	4278_C_L10	Cremated. **1)** Extant posterior neural arch and R. Apophysis of cervical vertebra exhibit fracturing with loss of superior lamina and superior R. Apophyseal facet, forming consistent, v. flat, smooth, stained fractrue surface - **Probable/definite peri-mortem SFT.**

53	4278_F_L9	**1)** Long oblique, linear fracture outline down across proximal L. Femur (with entire Gt. Trochanter fractured, missing), just clipping posterior lateral aspect of femoral head also, forming consistent, v.flat, stained fracture surface - **Probable peri-mortem SFT (Massive blow possibly proceeding proximally from distal & from lateral to medial (possible evidencec of polished cortical surfaces?) - suggesting victim potentially on floor with leg(/s) up/in air, possibly using them in defence??).** **2)** There is also a small, well-defined area of slight depression to the inferior posterior maergin of the L. Femoral head - **Possible peri-mortem BFT?** L. Femoral head diameter = 45.3mm (standard), max. = 45.3mm. Sampled for C/N.
54	4278_F_L9	Unburnt; id and siding not certain Slight OP to margins of proximal base; **1)** V. flat-looking fracture surface, with possible polish(?) across right dorsal aspect of proximal diaphysis (looking distally along dorsal diaphysis) - **Probable peri-mortem oblique SFT cut**;
55	4278_H_L10	Burnt/partially blackened; Siding reasonably certain**;** **1)** Extant R. Femur exhibits linear, flat-ish fracture surface through trabeculae of Gt. Trochanter - **Possible peri-mortem SFT cut (in sagittal plane down through greater trochanter of right femur).**
56	4284_(4278_F-D_L9)	See photos. No measurements. Sampled for C/N.
57	4284_(4278_F-D_L9)	See photos. No measurements.

58	4292_(4278_C_L9)	Extant proximal portion of R. Ulna suggests large size. **1)** Area of defined depression to posterior aspect of olecranon of R. Ulna, large hinged/depressed/retained fragment of cortical, associated with complete irregular oblique fracture across superior trochlear articular surface and loss of section of medial aspect - **Probable peri-mortem BFT (sharp-angled object?)?** **2)** There is also a small area of shallow depression to the posterior aspect of the extant proximal diaphysis - **Possible peri-mortem BFT? Alternatively post-mortem crushing in situ/erosion?**

59	4293_(4278_D-F_L10)	SUBADULT/Younger Adult - epiphyseal line of distal L. Femur still evident and not fully fused along posterior aspect, femoral head epiphyseal line also still evident. **1)** Small, relatively well-defined area of depression to anterior superior tip of Gt. trochanter of L. Femur - **Possible peri-mortem BFT?** **2)** Complete irregular transverse fracture to proximal diapysis, just inferior to Lesser trochanter, with irregular roughened/spicular fracture surface which exhibits variable staining - **Possible peri-mortem BFT? 3)** V. Slight, small, circular depression to posterior medial surface of midshaft - **Possible peri-mortem BFT? Not certain.** **4)** Quite sharp incipient enthesis(?) to medial aspect of linea aspera, just below midshaft - odd for such a young individual - **Possible antemortem trauma - myositis ossificans?** **5)** Complete oblique/spiral fracture to distal diaphysis, angled descending posteriorly from proximal to distal, with generally stained fracture surface, although some overlying recent post-mortem breakage also, with incomplete radiating fracture to posterior surface of distal metaphyseal fragment, stopping at incompletely fused epiphyseal line - **Probable peri-mortem BFT.** **6)** There is a large, well-defined (sub-rectilinear) penetrating lesion (max. ~26.6 x ~15.5mm) to the region of the anterior medial epicondyle, with hinged/depressed/retained fragments of cortical surface, irregular edges & somewhat stained fracture surfaces (difficult to be sure how old these are) - **Possible peri-mortem PFT/BFT?** **7)** There is also a small, relatively well-defined depression (max. 8.4 x 5.4mm) overlying the anterior medial articular margin of the medial condyle - **Possible peri-mortem BFT?** **8)** There is an additional incomplete radiating fracture proceeding from the mid-line of the unfused epiphyseal line forwards onto the central articular surface and then curving towards the small, sub-oval shallow depression to the anterior medial margin of the medial condyle. **9)** There is a quite straight linear, penetrating fracture/incision (max. 6.7mm long x ~0.7mm wide) to the inferior aspect of the medial articular margin of the medial condyle, immediately below the medial epicondyle - **Possible peri-mortem SFT? Not certain.** Femoral head diameter = 48.2mm (standard), max. = 48.4mm. Maximum bicondylar width (incompletely fractured!) = ~83.5mm. Sampled for C/N.
60	4305_(4180_QuadD)	**1)** Small, subtle spall (max. 5.8mm long x 5.0mm wide (linear edge)), with linear edge evident to posterior cortical surface of midshaft of R. Ulna, stained - **Possible/probable peri-mortem SFT (defence wound?).** Maximum length (fractured twice) = ~272.5mm.

61	4311_(4180_QuadD_L2_L.Femur_artic)	Articulated/associated with Sacrum/L. *Os coxae*. **N.B.** Also indirectly matched to (4180_QuadD_Top) R. *Os coxae*. **1)** Slight area of crushing within fracturing to anterior lateral femoral head. **2)** Well-defined, sub-trapezoidal-shaped penetrating lesion (max. 7.1 x 4.3mm) to inferior posterior aspect of Gt. trochanter, lies within associated large area of depression, with hinged/retained fragments of cortical and probable associated incomplete radiating fracture proceeding medially across intertrochanteric region - **definite peri-mortem projectile or PFT/BFT**. **3)** Fracturing with loss to anterior femoral head. **4)** Longitudinal, linear incision (10.8mm long, 0.75mm wide) penetrating into anterior aspect of proximal diaphysis. Difficult to say how deep, possibly only 2-3mm deep with flat-looking bottom (which might argue against a stab wound), but difficult to say - **Possible PFT/SFT (stab)? (There is a second possible linear incision/groove running parallel just medial to deeper incision, but this second is less obvious lying within the area of marked weathering/erosion). Alternatively these are taphonomic - adjacent area appears weathered.** Femoral head diameter (fractured with loss) = 46.6mm (extant max.). Sampled for C/N.
62	4203_B_L6_(SEcorner)	**1)** see Mandible (R.).
63	4247_(4278_B_L9)	See Case Study 1.
64	4247_(4278_B_L9)	See Case study 1.
65	4247_(4278_B_L9)	See Case study 1.
66	4247_(4278_B_L9)	See Case study 1.
67	4247_(4278_B_L9)	See Case study 1.
68	4247_(4278_B_L9)	See Case study 1.
69	4247_(4278_B_L9)	See Case study 1.
70	4213_(4203_A_L7)	**1)** Inferior aspect of L. Apophysis and neural arch of C4 vertebra exhibit very consistent slightly oblique linear fracture outline, with very flat/smooth and stained fracture surface, with linear incision continuing across posterior aspect of R. Apophysis, indicating focus of blow was on left side. There is also a small incomplete radiating fracture to the superior margin of the extant mid-L. neural arch, likely associated with this heavy sharp force injury. Inferior L. apophyseal facet, inferior half of neural arch inc. spinous process fractured and missing - **Definite peri-mortem SFT (Heavy cut to back of mid-neck region, most likely directed from behind and left of individual).**

71	4304_(4180_QuadD)	**1)** C4 vertebra has effectively been bisected in an almost horizontal transverse plane, with very consistent, flat/smooth and stained fractures surfaces - **Definite peri-mortem SFT (Heavy cut to back of mid-neck region, likely directed from behind, possibly from left of individual - possible/probable decapitation blow?**). **2)** There is also a very thin linear incision evident to the posterior surface of the inferior R. Neural arch lamina, continuous with the lateral right aspect of the main fracture surface, but at a slightly different alignment, suggesting the probability of a 2nd cut to this vertebra (Moderate blow to back of mid-neck region, again directed from behind and left of individual, most likely pre-dating the main transection of the vertebra) – **Definite peri-mortem SFT.**
72	4304_(4180_QuadD)	**1)** Superior R. Apophyseal of C5 vertebra has been transected, with very consistent, flat and stained fractures surfaces. Majority of neural arch and spinous process fractured and missing. Posterior aspect of L. Apophyseal surface exhibits very thin linear incision continuous with area of fracture/loss, which aligns well with line of transected R. Apophyseal facet - **Definite peri-mortem SFT (Heavy blow to back of mid-neck region, most likely directed from behind and left of individual).**
73	4271_(4203_G_L5-L6)	**1)** Extant C5 vertebra exhibits consistent almost horizaontal transverse fracture outline to inferior L. Apophysis and body, with consistent, flat, stained fractures surfaces - **Definite peri-mortem SFT (Heavy cut to back of mid-neck region, most likely directed from behind). N.B. The superior aspect of the base of the spinous process and the extant R. neural arch lamina also exhibit at least one linear-looking fracture outline, with a smooth, stained fracture surface, suggesting the possibility of an additional one or even 2 other peri-mortem cuts to the C5 vertebrae.**
74	4147_TorsoC	See Case study 2.
75	4147_TorsoC	See Case study 2.

76	4150_SkullA	**L. Petrous sampled for DNA**. Anterior R. TMJ and posterior EAM (2 fragments) of R. temporal only (cremated (white/black/brown) (heat-line)) - uncertain if this definitely belongs to same individual or not. Anterior half of L. Occipital condyle only, no R. occipital condyle(?). **1)** Incomplete, radiating fracture to anterior superior aspect of extant R. Parietal, with slight plastic deformation evident (depression/inflection of superior margin of fracture. There is also a slight small incomplete radiating fracture to the anterior L. Frontal, proceeding anteriorly away from the coronal suture, again with some probable plastic deformation - likely a result of the same BFT injury - **Possible/probable peri-mortem BFT (Blow to superior right side of head)?** **2)** The posterior aspect of the extant L. Parietal exhibits a very straight and consistent, oblique, linear fracture outline, fully penetrating both inner and outer tables, with consistent, flat/smooth, stained fracture surface, in addition to at least two other major radiating fractures to the posterior lateral L. parietal, running almost perpendicular to the first. There is also a possible large cortical shave defect to the extant L. central squamous occipital, but this may alternatively be a result of post-mortem breakage following thermal alteration as the extant occipital exhibits marked burning/blackening to its central and right squamous portion. The anterior L. Parietal and L. Frontal also exhibit consistent post-mortem fracturing with loss suggesting this region/side of the head had possibly been subject to substantial previous trauma - **Probable/definite peri-mortem BFT or possibly combination of SFT/BFT (Heavy blow obliquely to posterior left side of head and/or back of head)?** **3)** There is a small, incomplete, radiating fracture to the extant R. orbital roof, emanating from the fractured glabellar region - **Possible peri-mortem BFT (Heavy blow to Glabella)?** **4)** There is a possible triangular penetrating lesion to the region of the L. Asterion, however it is difficult to say for definite as at least part of the 'fracture' margin (anteriorly) looks very sutural in form/texture, although the superior aspect looks very flat, almost 'polished' - **Possible peri-mortem PFT or SFT/Stab (to posterior left side of head)? Alternatively an asterionic Wormian bone lost subsequent to the radiating fractures across the lambdoid and parietal notch regions? N.B.** Marked weathering to anterior right side of head, with delamination/flaking of cortical bone surface.
77	4164_SkullB	**R. Temporal sampled for DNA. 1)** Posterior aspect of inferior R. Mastoid process exhibits fracturing with loss, with oblique linear fracture outline to superior aspect of fracture and flat-looking, stained fracture surface in general – **Possible peri-mortem SFT (Light/glancing blow obliquely to right side of head)?**

78	4301_(4180_QuadC)	L. Petrous unburnt, fragmented. R. Petrous unburnt. **L. Petrous sampled for DNA**; R. Petrous identified for DNA sampling**;** **R. Parietal sampled for C14.** **N.B.** Only small posterior fragments of L. and R. Parietals present. Only R. Greater wing of sphenoid present. L. Petrous >75% complete (+ Parietal notch, EAM, mastoid process). R. Petrous almost complete; SFT to inferior mastoid process. **1)** V. straight, oblique, linear fracture across superior aspect of R. Mastoid process, with v. flat fracture surface including 'polished' cortical fracture surface and exposed trabecular/sinus, main (inferior) portion of mastoid missing - **Definite peri-mortem SFT (heavy cut to R. jaw/cheek.** **2)** There is a slightly irregular incomplete fracture to the R. Zygomatic root, with no/v.slight soil staining. There is also a complete fracture across the temporo-zygomatic suture! - **Possible peri-mortem BFT (Possibly associated with SFT to R. jaw/cheek)? Alternatively old post-mortem breakage.** **3)** There is an irregular transverse fracture (old) to the base of the L. Squamous temporal, appears to have completely transected superior squamous temporal - fracture section above the L. Mastoid appears angular/shaped (polygonal) and crosses squamo-parietal sutural junction! - **Probable peri-mortem BFT (heavy blow (edged/shaped BFT) or PFT)? Alternatively old post-mortem breakage?** **4)** There is 'windowing'/macroporosity to the superior endocranial aspect of the L. Petrous portion/base of the squamous temporal - **Possible antemortem pathology? Alternatively taphonomic or old post-mortem breakage?** **5)** There is slight evidence of new/remodelled bone to the endocranial surface within the L. Sigmoid sulcus, with slight vessel impressions also evident - **Possible antemortem (healing?) non-specific infection/reactive process?** **6)** There is an old fracture, transverse & slightly oblique across the posterior L. Parietal, just above the L. Lambdoid suture, with internal (slight) & external spalling - **Possible peri-mortem BFT (heavy blow) or even SFT (heavy) (oblique/horizontal)?** **7)** The R. Zygomatic exhibits unusually defined raised area to mainly orbital surface/orbital margin of its frontal process - a definite bump, which breaks the line of the orbital surface - **Possible antemortem (healed) trauma? (There is a very slight bump in a similar position in the L. Zygomatic but nowhere near as pronounced - X-RAY MIGHT BE BENEFICIAL HERE)** **N.B.** Some slight evidence of burning to the L. Parietal region. SEE PATHOLOGY RECORDING SHEET & WORD FORM FOR MORE DETAILS.

79	4304_(4180_QuadD)	L. Petrous unburnt. R. Petrous very blackened/charred compared to ectocranial Temporal. L. Petrous identified for DNA sampling; **R. Petrous sampled for DNA.** L. Petrous >75% complete (+ Squamous, parietal notch, EAM, TMJ & mastoid process), possible antemortem pathology to mastoid process? R. Petrous >75% complete (+ Parietal notch, EAM & mastoid process), possible antemortem pathology to jugular canal(?). Alveolar process of L. and R. Maxillae only (inc. sockets for T18-T25). **1)** There is a square/rectilinear hole (or penetrating lesion?), penetrating completely through both inner and outer tables of the cranium, just lateral of the sagittal suture and superior to lambda, with probable slight evidence of internal spalling and slight post-mortem breakage also evident - **Probable peri-mortem PFT (either due to arrow/bodkin/bolt or top spike of a war hammer or pike)? Alternatively old post-mortem breakage? (SEE PATHOLOGY DESCRIPTION IN FULL ON WORD FORM)** **2)** There is a slight depression evident to the area of the posterior L. Frontal and anterior L. Parietal, with additional incomplete fractures radiating across the endocranial surface of the area, evidence of both internal and external spalling, possibly complicated by possible evidence of SFT? - **Probable peri-mortem BFT? (SEE PATHOLOGY DESCRIPTION IN FULL ON WORD FORM).** **5)** There is an incomplete transverse fracture proceeding inwards (medially) from the lateral aspect of the broken R. Greater wing of the sphenoid, evident on both the ectocranial and endocranial surfaces, lateral and anterior of the foramen rotundum - Possible peri-mortem BFT (possibly associated with other injuries)? **6)** There is a fracture to the R. Frontal with an associated rectilinear lesion adjacent and perpendicular to the right lateral aspect of the coronal suture, with some slight post-mortem breakage also apparent - **Possible peri-mortem PFT?** **7)** There is a linear fracture with some internal spalling to the posterior lateral aspect of the R. Parietal and R. lateral aspect of the supraoccipital, appears to cross the R. Lambdoid suture, with at least 1 incomplete radiating fracture apparent - proceeding medially from the broken margin close to the R. Parietal boss towards the sagittal suture. There is 1 other slight incomplete linear fracture to the R. Supraoccipital region proceeding inferiorly from the inferior right corner of the right portion of the bipartite inca bone - **Probable peri-mortem BFT (to lateral aspect of R. Parietal)?** **8)** There is a linear fracture to the lateral aspect of the R. Zygomatic, with the separation/loss of the lateral aspect of the element (the majority fo the temporal process is missing) - **Probable peri-mortem BFT (to R. cheek)? 9)** Marked vessel impression to surface of R. Sigmoid sulcus, with possible deeper, irregular lesions also (rounded margins) - **Possible/probable antemortem (healing?) pathology?**

		10) Bilateral non-specific periostitis within maxillary sinuses - **Probable antemortem (healing?) sinusitis?** Slight cribra orbitalia evident to both orbital rooves (vessel impressions).

80	4213_A_L7	L. and R. Petrous portions identified for DNA sampling (not sampled). **1)** Opening to R. Jugular canal (i.e. just lateral of R. Occipital condyle) appears enlarged compared to left side - **Possible antemortem pathology?** **2)** The line of the nasal septum/vomer appears deviated and bulges towards the left side - **Possible antemortem pathology?** **3)** There is marked resorption of the alveolar process along the entirety of both the maxillary and mandibular dental arcades - **Probable marked periodontitis** (associated with calculus build-up and dental caries to the R. Maxillary M3 and L. Maxillary Pm1). **4)** There is a large chip/section missing from the mesial/occlusal aspect of the extant enamel crown of the L. Maxillary Pm2, appears old, rather than recent post-mortem breakage - **Possible peri-mortem breakage due to peri-mortem BFT?** **5)** There is an irregular lesion to the medial anterior aspect of the L. Mandibular fossa, with possibly raised/remodelled margins - **Probable antemortem (healed?) trauma (osteochondritis dissecans-type lesion?)? Alternatively possible lytic lesion, possibly due to infective process?** **6)** There are mutiple incomplete, radiating fractures to the centre of the occipital, apparently underlying the slightly charred surface whgich has partially flaked/broken away in places - difficult to say whether there has been some healing or not or if the burning/charring has caused subsequent breakage. The inion protuberance also appears to be slightly fractured with some loss. There is a single linear, incomplete but open fracture just visible on the endocranial surface (through the foramen magnum - **Probable peri-mortem BFT (blow to the back of the head, slightly on left)?** **7)** The L. Mastoid process exhibits distinctive unusual morphology with a marked fossa/(???) lesion to the lateral posterior aspect of the middle portion of the process, <u>not</u> bilateral - **Possible antemortem (Healed?) trauma/pathology (potentially associated with probable osteochondritis dissecans-type lesion in L. TMJ)?** **8)** There is an area of breakage to the mid-section of the sagittal suture, c.3cm superior to the R. Parietal foramen, with possibly 'shaved' appearance to the ectocranial surface and some possibly deeper damage(?) - Not certain. **9)** There is a large, irregular area of surface morphology to the lateral anterior aspect of the R. Mandibular fossa, necrotic in appearance, with some remodelling, not nearly as well-defined as lesion observed in the left TMJ - **Possible antemortem (healed?) trauma (dislocation of R. jaw joint due to trauma)? Alternatively possible OA to jaw joint.**

81	4271_(4203_G_L5-L6)	Unburnt. **L.Petrous sampled for DNA.** L. Petrous 50-75% complete (+ Squamous, parietal notch, EAM, TMJ & mastoid process), Zygomatic root = v. male. **1)** There is a linear/rectilinear depression obliquely aligned across the inferior anterior aspect of the R. Frontal, just superior to the supraorbital ridge - **Probable antemortem (well-healed) trauma (probable well-healed SFT or edged BFT?).** **2)** There is a massive opening/fracture to the superior aspects of both L. and R. Parietals and the superior aspect of the extant Frontal, essentially from bregma back along the sagittal line to lambda, with irregular fracture margins, both internal and external spalling. There is severe blackening/burning around the L. fracture margin and posterior and posterior R. fracture margins which have probably resulted in additional post-mortem fragmentation of the fracture margins. There appear to be old/(peri-mortem?) radiating fractures across the R. Parietal, but there is post-mortem breakage also evident, especially to the L. Parietal - **Probable peri-mortem BFT (Heavy blow) with subsequent burning? Alternatively possible peri-mortem SFT (heavy blow)? Or post-mortem breakage due to burning?** **3)** There is complex fracturing of the external occipital protuberance region, with at least 1 incomplete, radiating fracture, in addition to both internal and external spalling - the internal spalling to the endocrnial surface just inferior to lambda looks markedly peri-mortem - **Probable peri-mortem BFT (heavy blow to back of head, complicated by subsequent burning)?** **4)** There is a small, rectilinear section of bone missing just inferior and lateral to the R. Parietal boss region, with fracture margins appearing old and some internal spalling - **Possible peri-mortem PFT? Alternatively possible peri-mortem shaped BFT or old post-mortem breakage?** **5)** There is a very straight transverse fracture to the L. Maxilla, superior to the distal/posterior alveolar, just below the position of the zygomaticomaxillary suture, fracture exhibits almost 'polished appearance' - **Possible peri-mortem SFT (across face, just below left cheek)? Alternatively possible peri-mortem BFT or old post-mortem breakage?**

82	4203_F_L8	**1)** There is a large open fracture to the posterior aspect of the lateral L. Parietal, lateral of the L. Parietal boss, with at least 1 major radiating fracture to the lateral posterior L. Parietal. The fracture margins exhibit both internal and external spalling, with the majority of the fracture margins stained, although there is some recent post-mortem breakage evident including a complete post-mortem fracture. **N.B.** A hinged fragment was attached to part of the shaped(?) fracture margin (see diagram), now detached but retained in separate bag. - **Probable peri-mortem BFT (min. 1 x heavy blow to left side of head, possibly by shaped /edged weapon/object)? Alternatively old post-mortem breakage?**
83	4203_A-C_L8-9	**1)** There is a large incomplete, open fracture to the anterior aspect of the lateral R. Parietal, associated with warping/deformation of overall cranial shape, with several smaller, radiating fractures - Probable peri-mortem BFT (Massive blow to right side of head/right temple (R. Temporal present))? Alternatively old post-mortem deformation/breakage due to overburden? **2)** There is a large section of the inferior lateral L. Parietal missing, with the extant fracture margins exhibiting slight evidence of spalling in places and at least 1 radiating fracture with an associated hinge fracture. **N.B.** The endocranial aspect of the radiating fracture exhibits spalling/loss of the internal table/surface - **Probable peri-mortem BFT (to left side of head)?** **3)** There is a large central section of the Frontal missing, close to glabella, with fracture margins exhibiting an internal bevel and a possible very small external hinge fracture to the midline of the extant fracture margin. There are several radiating fractures to the Frontal towards the lateral left side, with some spalling in the epipteric region. **N.B.** It's difficult to say whether (2) and (3) are completely separate or if there are more fractures/injuries between them? - **Possible peri-mortem BFT/PFT (to anterior forehead)?** Alternatively old post-mortem breakage? **4)** There is a complete irregular fracture to the posterior half of the R. Squamous temporal, separating the majority of the Squamous temporal from the R. Mastoid process, with smooth-looking, stained fracture surfaces - **Probable peri-mortem BFT (to right side of head/jaw, probably associated with (1) or (5))?** **5)** The posterior and inferior aspects of the R. Mastoid process are fractured/missing, with superior fracture margin exhibiting either old post-mortem breakage or peri-mortem charcteristics - difficult to be certain which. - **Possible peri-mortem BFT (blow to posterior right side of head)? Alternatively associated with (1)?**
84	4247_(4203-4278_B_L6-9)	See Case study 1.

85	4203_G_L6	**1)** Significant fracture across anterior mandible/mental eminence, with irregular fracture margins and exposure of trabecular bone/spalling of anterior cortical surface, possibly originally curvilinear, there is evidence of some burning/charring to lingual aspect of fracture margin and an incomplete radiating fracture, so it's possible thermal alteration has caused some subsequent post-mortem breakage(?) - **Probable/definite(?) peri-mortem BFT (Heavy blow to chin/left side of jaw?)**
86	4234_(4203_H_L8)	**4)** There is small nick/chipped section of bone (c.8mm long x 2-3mm deep) missing from the L. Gonion of the Mandible. It is uncertain whether the fracture margin is peri-mortem or post-mortem (e.g. crushing) - **Possible peri-mortem SFT/BFT?** **5)** There is a complete fracture running down across the anterior L. body of the Mandible, associated with both the L. Mental foramen and a small area of missing bone in the anterior cortical surface (max. 7.3mm x max. 5.3mm), inferior and anterior superior aspects of fracture (i.e. labial margins) exhibit peri-mortem characteristics, lingual aspects exhibit post-mortem characteristics - **Probable peri-mortem PFT/BFT (to anterior left jaw)? Alternatively simply peri-mortem BFT (to left? side of jaw), with associated comminution/loss of bone?**

87	4180_QuadB	**MATCHED** to L. Mandible (4180_QuadB). See Mandible (L.) for general description. **1)** (see Mandible (L.)). **2)** Shave defect to buccal aspect of posterior margin of R. Mandibular ramus, with 'polished' cortical surface (max. 7.6mm wide x c.6.0mm tall) and inferior end-fracture/spalling/breakaway spur - **Definite peri-mortem SFT (light blow to posterior right jaw, directed from right side from above) (PHOTOGRAPHED)**. **3)** Matched R. Coronoid process exhibits quite linear, oblique fracture outline with stained, flat-looking fracture surface, appears associated with another almost perpendicular oblique fracture down across the R. Ramus, which has a small section missing just inferior to position of R. Coronoid process - **Possible/probable peri-mortem BFT or combination of PFT/BFT (Blow to right side of jaw, possibly associated with light SFT to posterior buccal aspect of R. Ramus?)? (PHOTOGRAPHED)** **4)** Shave defect to inferior margin of central/anterior mandible, focussed on right side, exhibits v. straight, slightly oblique transverse fracture outline with'polished' cortical surface and probable breakaway wall evident **(MEASUREMENTS NEEDED)**, proceeds superiorly and mesially from right to left, ends within tubercle/muscle attachment - **Definite peri-mortem SFT (light-moderate blow to inferior chin/upper throat region directed from right to left)(PHOTOGRAPHED)**. **N.B.** In total, this mandible exhibits a minimum of 2 definite peri-mortem SFT cuts (both shave defects); a minimum of 1-2 peri-mortem BFT (1 definite to anterior mandible; 1 probable/definite to R. coronoid; 1 possible/probable to L? coronoid); 1 possible PFT (R. Mandibular ramus); and 1-2 possible peri-mortem SFT incisions to lateral aspect of L. condyle.
88	4203_B_L6_(SEcorner)	**1)** Inferior half of entire R. Mandibular body has been transected and is missing, with very straight, horizontal linear extant fracture outline with very flat fracture surface with substantial 'polished' cortical - **Definite peri-mortem SFT (Heavy blow from very sharp blade across right side of jaw at least, with associated BFT fractures also evident).**

89	4203_B_L6_(SEcorner)	Originally bagged with (4247). **1)** Medial fracture outline of extant anterior mandible and L. Mandible exhibits curvilinear fracture outline, with stained fracture surface and large incomplete radiating fracture across both buccal and lingual surfaces of L. Mandibular body, and slight plastic deformation evident - **Probable/definite peri-mortem BFT or combination of BFT/PFT (heavy blow to anterior mandible/chin)?** **2) N.B.** The L.Mandibular condyle has been separated from the ramus by an irregular fracture, fracture surface relatively unstained, although there is evidence of spalling on the posterior lingual aspect which is stained, possibly originally an incomplete fracture which has since completely broken post-mortem - **Possible/probable peri-mortem BFT (Blow to left side of jaw, possibly associated with (1))?**
90	4278_A_L9	Partially burnt/blackened (heat-line). **1)** Posterior aspect of R. Condylar neck exhibits very consistent oblique curvilinear fracture outline, with v. flat, stained fracture surface with 'polished' cortical - **Definite peri-mortem SFT (heavy blow to posterior right side of head at least).**
91	4150_SkullA	Partially cremated (white/black) (heat-line). **1)** There is a small, oblique linear incision into the inferior posterior aspect of the R. Apophysis of the C2 vertebra, with some very slight plastic deformation evident - **Definite peri-mortem SFT (Moderate cut at least to back of neck most likely directed from left side).** **2) N.B.** The L. Lateral tip of the C2 spinous process exhibits a very flat-looking possible fracture outline, with flat surface and possibly exposed trabecular - this may well represent additional SFT, if so likely associated with same injury causing (1) as they are in moderate alignment.
92	4180_QuadD	Cremated (white). **1)** Very straight, very thin oblique linear incision across superior surface of spinous process of cervical vertebra, proceeds anteriorly from left to right - **Definite peri-mortem SFT (Light/glancing cut across back of neck, likely directed from behind and left of individual).** **2)** Inferior surface of extant spinous priocess of cervical vertebra exhibits consistent horiozntal transverse fracture outline, with very flat/smooth and stained fracture surface - **Probable peri-mortem SFT (Heavy cut across back of neck)?**
93	4259_(4203_E_L7)	See photos.
94	4259_(4203_E_L7)	See photos.
95	4259_(4203_E_L7)	See photos.

96	4246_(4203-4278_A-B_L6-L9)	See Case study 1.
97	4246_(4203-4278_A-B_L6-L9)	See Case study 1.
98	4246_(4203-4278_A-B_L6-L9)	See Case study 1.
99	4151_TorsoB	**1)** Anterior surface of sternal rib shaft of 1 L. rib exhibits large area of depressed cortical bone delineated by incomplete fractures (with plastic deformation?), (there is also a complete fracture through the area of depression which is possibly due to post-mortem breakage) - **Probable/definite peri-mortem BFT (to L. Chest region)?** **2)** There is also a complete irregular fracture to the same L. rib, more proximal than the area of depression, just distal to the angle - **Possible peri-mortem BFT (to L. Chest region, potentially related to the probable peri-mortem BFT represented by the area of depression?)?**

APPENDIX A8: Antemortem Changes

Table 52: Summary of all cranial and postcranial antemortem trauma and other antemortem pathology.

Burial No.	Context/ Location	AM Type?	Age category	Bone element affected	Area affected	Status of healing
110	4164	Pathology? (Osteoma?)	Adult?	Parietal (R.)	Superior Anterior	Healed
110	4301	Pathology?	Adult?	Temporal (L.)	Superior endocranial surface of Petrous	Unhealed?
110	4301	Non-specific Periostitis	Adult?	Temporal (L.)	Sigmoid sulcus	Healing?
110	4301	Pathology/ Trauma?	Adult?	Zygomatic (R.), (possibly bilateral?)	Orbital surface/ margin	Healed?
110	4304	Non-specific Periostitis	Adult?	Temporal (R.)	Sigmoid sulcus	Healing/ Healed?
110	4304	Non-specific Periostitis	Adult?	Maxilla (L.+ R.)	Maxillary sinus	Healing/ healed?
110	4213	Pathology?	Adult	Temporal/Occipital (R.)	Jugular canal	Healing/ healed?
110	4213	OC?	Adult	Temporal (L.)	TMJ	Healed
110	4213	Trauma? (OC/Dislocation)?/ OA?	Adult	Temporal (R.)	TMJ	Healed?
110	4203_H_L5	Pathology?	Adult?	Parietal (L.)	Ectocranial surface of Parietal boss region	Healed?
110	4203_B_L7	Pathology/ Trauma?	Adult?	Mandible (R.)	Inferior lingual surface of lateral mandibular body	Well-healed
110	4203_B_L4	OA?	Adult?	Clavicle (L.)	Lateral articular surface	Healing?
110	4203_G_L6	OA?	Adult?	Clavicle (L.)	Medial & lateral articular surfaces	Healing?
110	4203_B_L4	OA?	Adult?	Clavicle (R.)	Medial articular surface	Healing?
110	4203_C_L6	STT-MyoOss	Adult?	Scapula (L.)*	Coracoid	Well-healed(?)
110	4203_C_L6	BFT?	Adult?	Scapula (L.)*	Scapular neck	Well-healed
110	4203_A_L6	BFT?	Adult	Scapula (R.)	Glenoid cavity	Well-healed
110	4203_C_L7	OA? (/RCS?/Pathology?)	Adult?	Scapula (R?)	Glenoid cavity	Healed

110	4203_B_L6	RCS?	Adult?	Humerus (L.)	Posterior Gt. tubercle	Healing?
110	4203_E_L8-L7	Pathology/RCS/OA?	Adult?	Humerus (L.)	Humeral head & anterior margin	Healed?
110	4203_F_L6	OC?	Adult?	Humerus (L.)	Inferior Trochlea	Well-healed
110	4278_D_L9	OA?	Adult?	Humerus (L.)	Capitulum	Healing?
110	4203_F_L6	OC?	Adult?	Humerus (R.)	Inferior central trochlea	Well-healed
110	4217	Pathology/RCS?	Adult?	Humerus (R.)	Bicipital groove	Healed?
110	4274	Pathology/RCS?	Adult?	Humerus (R.)	Humeral head margins, bicipital groove	Healed?
101	4147	OC?	Adult?	Ulna (L.)	Central trochlea surface	Healed
101	4149	OC?	Adult?	Ulna (L.)	Central trochlea surface	Healed?
101	4174	STT?	Adult?	Radius (R.)	Radial tuberosity	Healing/ healed?
110	4278_F_L11	OA	Adult?	Radius (R?)^	Radial head	Healing?
110	4180_QuadB	Pathology/ Trauma?	Adult?	Scaphoid (L.)****	Marked OP/ entheses	Healed?
110	4180_QuadB	Pathology/ Trauma?	Adult?	Hamate (L.)****	Marked OP/ entheses	Healed?
110	4303	Pathology/ Trauma?	Adult?	Triquetral (L.)****	Marked OP/ entheses	Healed?
110	4303	Pathology/ Trauma?	Adult?	Triquetral (L.)****	Hamate-articulating surface	Healed?
110	4303	Pathology/ Trauma	Adult?	Pisiform (L.)****	Marked OP/ entheses	Healed?
110	4203_B_L4	Pathology/ Truama?	Adult?	Capitate (L.)	Marked OP/ entheses	Healed?
110	4203_D_L8	OA?	Adult?	Capitate (L.)	MC2/ Trapezoid- articulation	Healing?
110	4285	Pathology? (Subchondral cyst?)	Adult?	Scaphoid (R.)**	Sub-articular	Healing?
110	4285	Pathology? (Subchondral cyst?)	Adult?	Trapezium (R.)**	Sub-articular	Healing?
110	4288	Pathology/ Trauma?	Adult?	Trapezium (R.)	Palmar attachment site	Healed
110	4203_F_L6	Con/Dev Defect? (/Trauma?)	Adult?	Trapezoid (L.)	Palmar attachment site	Healing
110	4203_D_L8	OA?	Adult?	MC1 (L.)	Distal articular surface	Healing?
110	4258	OA(?)	Adult?	MC1 (L.)	Distal articular surface	Healing?
110	4180_QuadA	OA?	Adult?	MC1 (R.)	Palmar aspects of proximal and distal articular ends	Healing?
110	4203_C_L5	OA?	Adult?	MC1 (R.)	Palmar aspect of distal articular surface	Healing?

110	4203_D_L7	STT?	Adult?	MC5 (L.)	Dorsal medial aspect of proximal diaphysis	Healed?
110	4203_H_L5	STT? (Myositis ossificans)	Adult?	MC5 (L.)	Medial proximal diaphysis	Healed
110	4203_H_L5	OA?	Adult?	MC5 (L.)	Medial proximal diaphysis	Healed?
110	4268	STT?	Adult?	MC5 (L.)	Dorsal medial aspect of midshaft	Healed?
110	4203_B_L4	STT?	Adult?	Prox. H. Phal.	Distal head (unilateral)	Healed?
110	4203_C_L5	Pathology/ Trauma?	Adult?	Prox. H. Phal.	Distal Articular head (unilateral)	Healed
110	4203_E_L5	Pathology/ Trauma	Adult?	Prox. H. Phal.	Distal head	Healed?
110	4180_QuadA	Erosive Arthropathy?	Adult?	Inter. H. Phal.	Distal head (unilateral)	Healing?
110	4180_QuadB	Erosive Arthropathy?	Adult?	Inter H. Phal.	Distal head (bilateral)	Healing?
110	4223	OA?	Adult?	Inter H. Phal.	Distal head	Healing?
110	4278_A-C_L9	Non-specific Periostitis	Adult?	Inter. H. Phal. (U.)	Dorsal aspect of proximal end	Healed?
110	4152_FootA	OA	Adult?	Dist. H. Phal. (U.)	Articular surface (unilateral)	Healing?
110	4203_A_L7	OA?	Adult?	Dist. H. phal. (U.)	Palmar margin of proximal base	Healing?
110	4203_A_L7	OA?	Adult?	Dist. H. phal. (U.)	Dorsal & palmar margins of proximal base	Healing?
101	4148	OA	Adult?	Thoracic vertebra (T10)	Apophyseal facets?	Healing?
110	4180_QuadB_L2	Erosive Pathology?	Adult?	Thoracic vertebra (T10-T12)	Body surfaces	Healing?
110	4247	Fusion (/Trauma?)	Adult	Thoracic vertebra (T03)***	Inferior body surface	Healed?
110	4247	Fusion (/Trauma?)	Adult	Thoracic vertebra (T04)***	Superior body surface	Healed?
110	4203_G_L6	OA?	Adult?	Thoracic vertebra (U.)	L. Costal facet	Healing?
101	4147	Osteoma? (?non-specific Periostitis)	Adult?	Rib (L.)	Anterior sternal shaft	Healed
101	101-11	Pathology/ Trauma?	Adult?	*Os coxae* (R.)	Superior margin ofAcetabulum	Healed?

110	4206	Pathology/ Trauma?; Erosive lesion?; Periostitis; STT?	Adult	Femur (L.)	Femoral head; Anterior neck/head margin; Medial aspect of proximal shaft; Medial aspect of linea aspera at midshaft	Healed?; Healing?; Healed?; Healed?
110	4203_H_L5	OC? (/OA?)	Adult?	Femur (R.)	Inferior central aspect of distal articular surface	Healing?
110	4203_B_L6	Pathology/ Trauma?	Adult?	Patella (L.)	Inferior medial aspect of anterior patella	Healed?
110	4203_G_L5	OA? (/OC?)	Adult?	Patella (L.)^^	Centre of lateral articular surface	Healed?
110	4203_G_L5	OC?	Adult?	Patella (L.)^^	Lateral aspect of lateral articular surface	Healed
110	4278_F_L9	OC(?)	Adult?	Patella (L.)	Central articular surface	Healed
110	4291	OC? (/Pathology/OA?)	Adult?	Patella (L.)	Superior articular surface	Unhealed/ healing?
101	4155	OC	Adult?	Patella (R.)	Centre of articular surface	Healed?
101	4158	Non-specific Periostitis? (/BFT?)	Adult?	Tibia (L.)	Diaphyseal	Healed?
101	4161	OC? (/Con/Dev defect?)	Adult?	Tibia (L.)	Talocrural surface	Healed
110	4203_A_L4	Non-specific Periostitis (Slight)	Adult?	Tibia (L.)	Medial anterior diaphysis	Healed?
110	4209	Osteochondroma/ STT?	Adult?	Tibia (L.)	Lateral aspect of proximal end.	Healed
110	4209	Non-specific Periostitis (Slight)	Adult?	Tibia (L.)	Medial anterior diaphysis	Healed?
110	4210	STT	Adult?	Tibia (R.)	Lateral aspect of distal end	Healed?
110	4210	Non-specific Periostitis (Slight)	Adult?	Tibia (R.)	Medial diaphysis	Healed?
110	4231	Non-specific Periostitis (Slight)	Adult?	Tibia (R.)	Medial diaphysis	Healed?
110	4236	Non-specific Periostitis (Chronic)	Adult?	Tibia (R.)^^^	Entire diaphysis	Healing/Healed?
110	4203_B_L4	OA?	Adult?	Fibula (L.)	Superior margin of distal articular surface	Healing?
110	4236	Non-specific Periostitis (Chronic)	Adult?	Fibula (L.)^^^	Majority of diaphysis	Healing/Healed?

110	4231	Non-specific Periostitis?	Adult?	Fibula (R.)	Proximal diaphysis	Healed?
110	4287	STT?	Adult?	Fibula (R.)	Anterior lateral aspect of distal end	Healed?
110	4215	OC?	Adult?	Talus (R.)	Posterior calcaneal surface	Unhealed/ healing?
110	4215	OA?	Adult?	Talus (R.)	Margins of Talar head	Healing?
110	4180_QuadD_Foot &Ankle	Dev/Con defect	Adult?	Med. Cuneiform (L.)	Partially bipartite	Healed
110	4180_QuadA	Congenital/ Developmental defect (/Trauma?)	Adult?	Lateral cuneiform (R.)	Fused to Inter. Cuneiform	Well-healed
110	4180_QuadA	Congenital/ Developmental defect (/Trauma?)	Adult?	Inter. cuneiform (R.)	Fused to Lateral Cuneiform	Well-healed
101	4163	STT? (MyoOss)	Adult?	MT5 (L.)	Superior aspect of proximal base	Well-healed
110	4180_QuadA	STT?	Adult?	MT2 (L.)	Dorsal lateral aspect of midshaft-proximal diaphysis	Healed
110	4180_QuadD	Erosive Arthropathy?	Adult?	MT1 (L.)	Medial aspect of distal head	Healing?
110	4203_D_L6	Pathology/ Trauma?	Adult?	MT (U.)	Superior lateral aspects of distal head	Healed?
110	4250	Non-specific Periostitis?	Adult?	MT2 (R.)+	Dorsal diaphysis	Healing/healed?
110	4250	Non-specific Periostitis?	Adult?	MT3 (R.)+	Dorsal diaphysis	Healing/healed?
110	4278_B_(Within_Jar6383)	Pathology/ STT?	Adult?	MT1 (U.)	Lateral aspect of Distal head	Healed
101	4171	OC	Adult?	1st Prox. F. Phal. (R.)	Centre of Proximal articular surface	Healing/ healed?
110	4180_QuadB	OC?	Adult?	1st Prox. F. Phal. (U.)	Proximal articular surface	Healed
110	4201_H_(2010)	OC?	Adult?	1st Prox. F. Phal. (U.)	Proximal base	Healed
110	4201_WestEnd_L1_E,F,G,H	OC	Adult?	1st Prox. F. Phal. (U.)	Proximal base	Healed
110	4180_QuadB	Pathology/ Trauma?	Adult?	Prox. F. Phal. (U.)	Distal Articular head	Healed?
110	4180_QuadD	Pathology/ STT/ BFT?	Adult?	Prox. F. Phal. (U.)	Distal Articular head	Healed/ healing?

110	4215	Erosive Arthopathy?	Adult?	Prox. F. Phal. (U.)	Margins of distal articular head	Healing?
110	4256	OA?	Adult?	Prox. F. Phal. (U.)	Distal articular head	Healing?
110	4203_F_L6	Pathology/ Trauma?	Adult?	Inter. F. Phal. (U.)	Midshaft (unilateral)	Healed?
110	4203_G_L4_(W.End)	OC?	Adult?	Inter. F. Phal. (U.)++	Distal articular head	Healed?
110	4203_D_L5	OC	Adult?	1st Dist. F. Phal. (L?)	Centre of articular surface	Healing/ healed?
110	4203_E_L4	OC	Adult?	1st Dist. F. Phal. (L?)	Lateral aspect of articular surface	Healing/ healed?
101	4152	OC? (/Pathology?/ Trauma?)	Adult?	1st Dist. F. phal. (R.)	Medial inferior margin of proximal base	Healing/healed?
110	4278_H_L10	STT (Myositis Ossificans)	Adult?	1st Dist. F. Phal. (U.)	Diaphysis (unilateral)	Healed
110	4233	OC?	Adult?	Dist. F. Phal. (R?)++	Articular surface	Healed?
110	4180_QuadA	Non-specific Periostitis?	Adult?	1st Prox. H? Phal. (R?)	Distal diaphysis (unilateral)	Healed?
110	4203_B_L4	OA?	Adult?	Small long bone fragment	Phalangeal?	Healing?
110	4203_B_L6	Non-specific Periostitis	Adult?	Long bone fragment	Diaphyseal	Healing?
110	4203_B_L6	Non-specific Periostitis	Adult?	Long bone fragment	Diaphyseal	Healing?
110	4203_D_L6	Non-specific Periostitis	Adult?	Long bone fragment	Diaphyseal	Healing?
110	4203_D_L6	Non-specific Periostitis	Adult?	Long bone fragment	Diaphyseal	Healing?
110	4203_G_L4	Non-specific Periostitis	Adult?	Long bone fragment	Unidentified	Healing/ healed?
110	4203_G_L7	STT? (Myositis ossificans)/ Ostochondroma?	Adult?	Small long bone fragment	Diaphyseal	Healed

*, **, ***, **** +, ++, +++, ^, ^^, ^^^ indicate associated or likely associated elements/lesions

Figure 105: A) Well-healed antemortem fracture to right scaphoid carpal; B) Partially healed Osteochondritis dissecans to the base a 1st proximal foot phalanx (unsided), indicating antemortem trauma to the great toe.

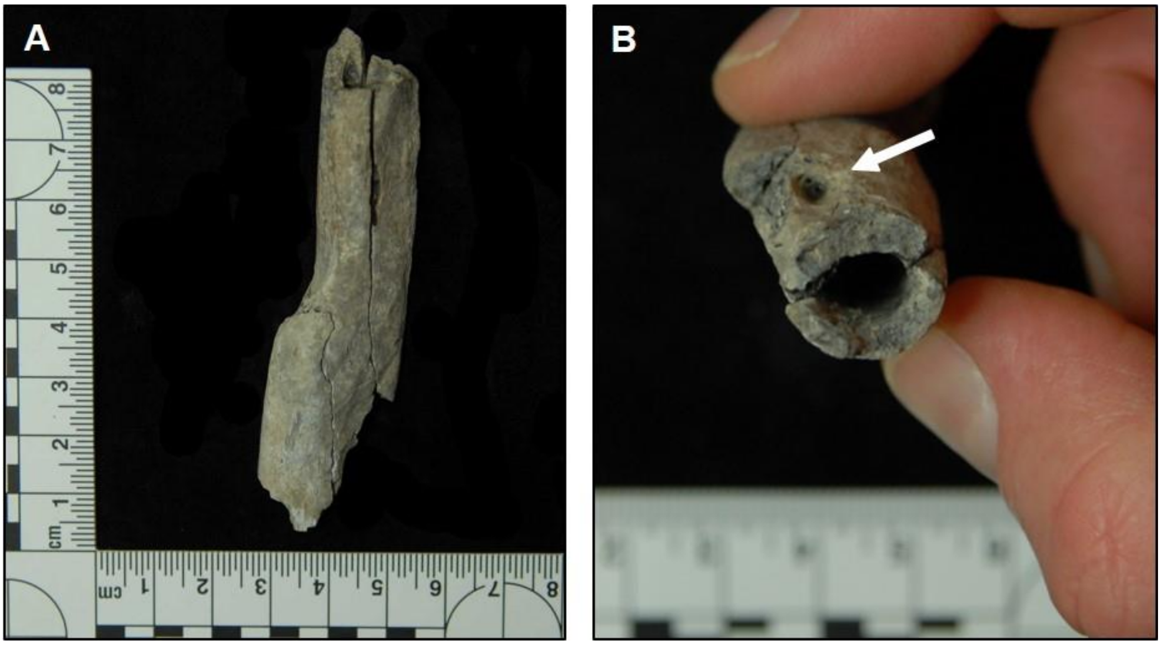


Figure 106: Well-healed antemortem fracture to probable radius (unsided), demonstrating malalignment of opposing fracture ends, with angulation and overlap, indicating a lack of reduction (A); and possible evidence of a cloaca (B, white arrow).

Figure 107: Context 4147 – Right hand, showing robust nature of right 1st metacarpal, possibly indicative of a well-healed antemortem fracture.

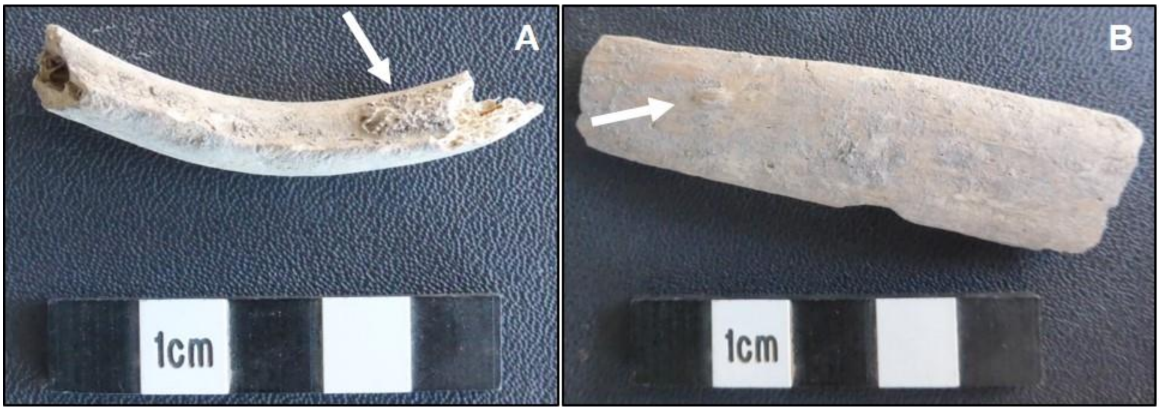


Figure 108: Context 4147 - Associated ribshaft fragments. A) fragment showing well-defined oval-shaped area of compact remodelled and speculated new bone to ventral surface and within costal groove. B) Fragment showing well-defined, raised oval area of compact remodelled and spiculated new bone to ventral surface and within costal groove. B) Fragment showing well-defined, raised oval area of compact remodelled bone to ventral surface (white arrow).

APPENDIX A9: Peri-mortem Trauma (Other Examples)

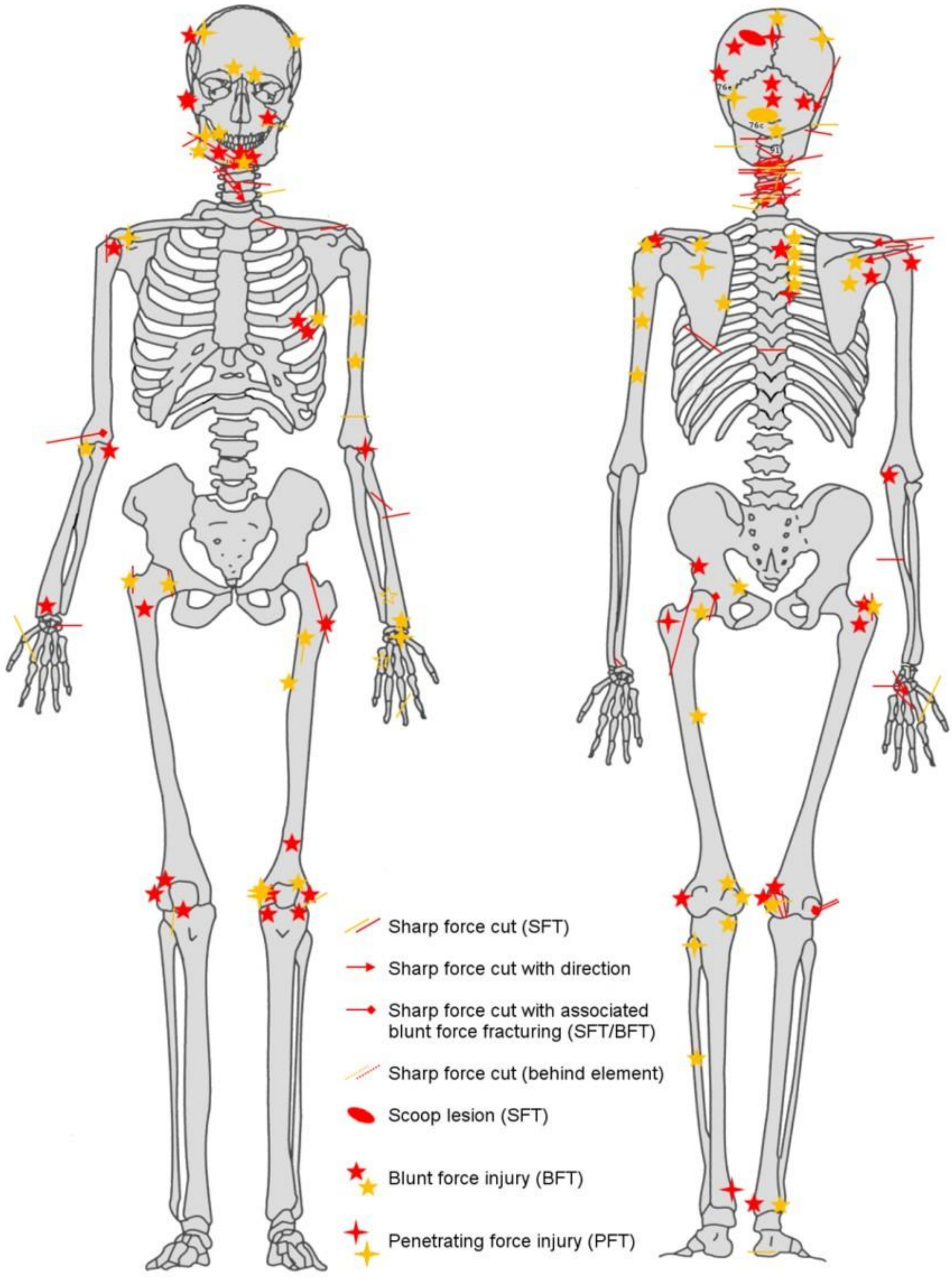


Figure 109: Distribution of all definite (high confidence = red) and probable (moderate confidence = yellow) peri-mortem traumata across anterior (left) and posterior (right) aspects of skeleton.

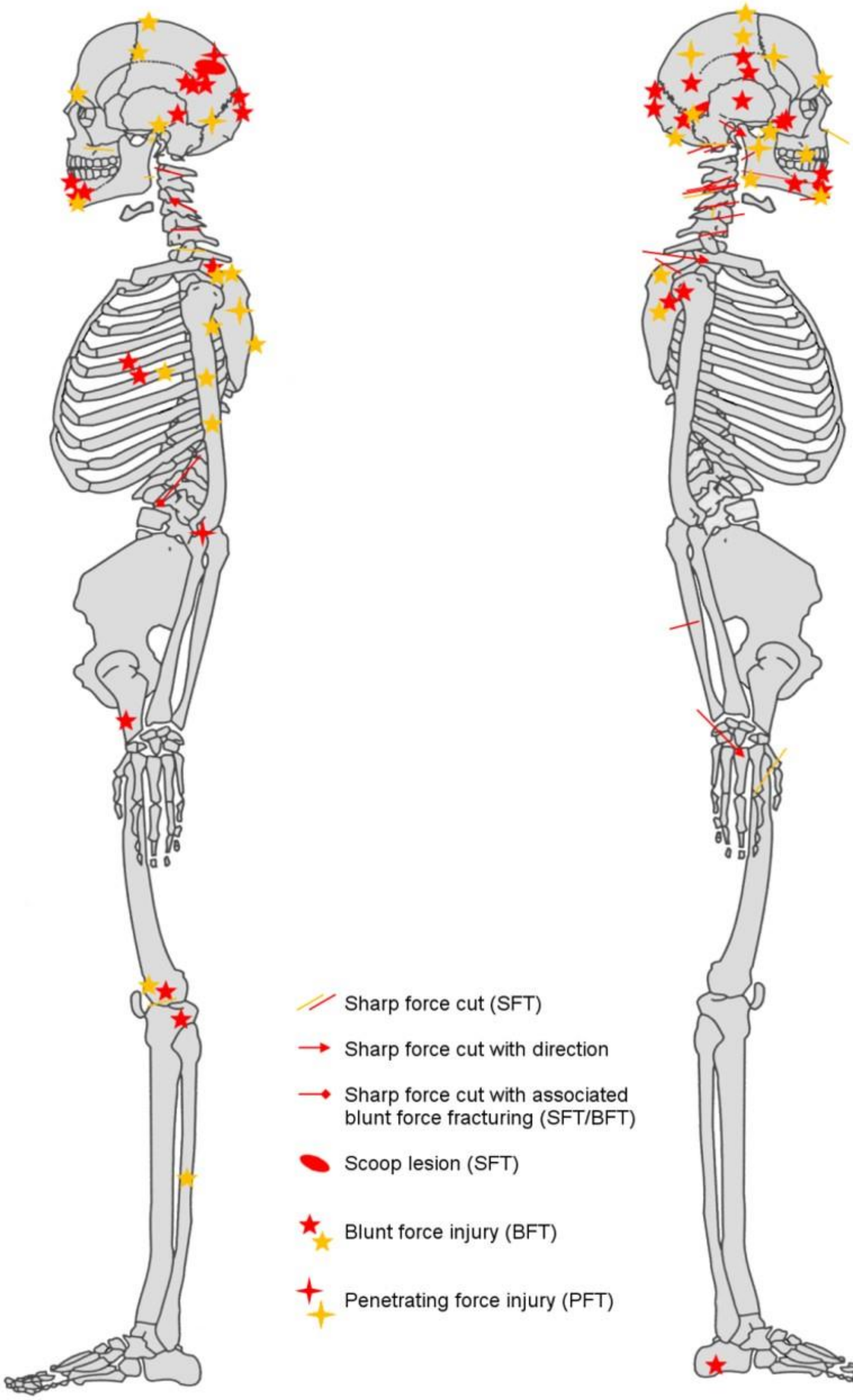


Figure 110: Distribution of all definite (high confidence = red) and probable (moderate confidence = yellow) peri-mortem traumata across left (left) and right (right) aspects of skeleton.

Figure 111: Burial 110, 4304, endocranial view of frontal cranial fragment, exhibiting large fracture to left side, with bevelled and stained fracture surface, highly suggestive of peri-mortem blunt force trauma (white arrow).

Figure 112: Burial 110, 4304, superior view of fitted cranial fragments demonstrating a well-defined trapezoidal (almost square) penetrating lesion to the superior left parietal (white arrow), highly suggestive of peri-mortem trauma and possibly representing either a projectile impact or alternatively a pointed or spiked weapon injury.

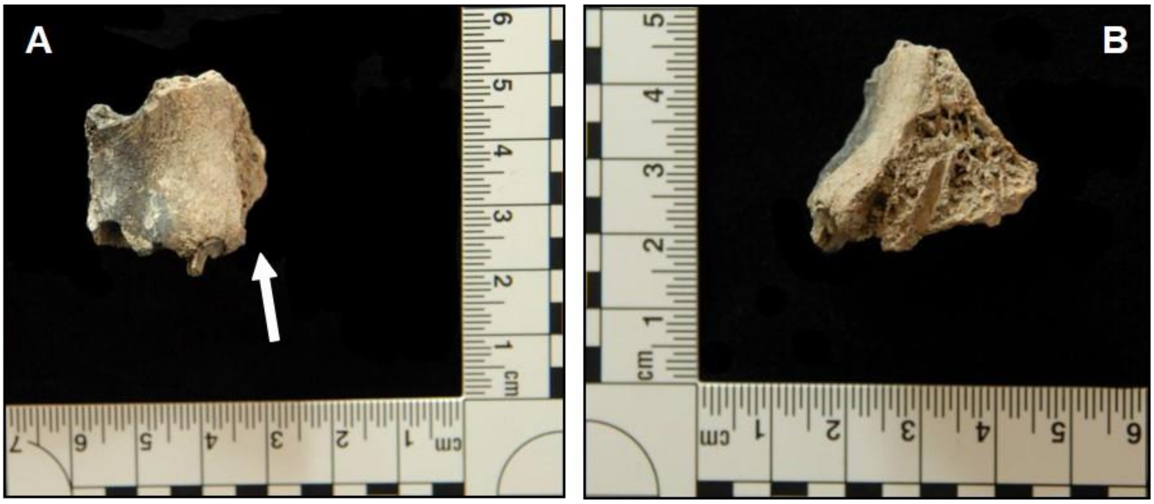


Figure 113: Burial 110, (4180_QuadB), anterior left maxillary fragment, exhibiting near vertical, very straight, stained fracture surface suggesting deeply penetrating sharp force cut down left side of face. Note the sharply-defined tooth root socket transected by the fracture. A) Anterior view; B) Lateral view.

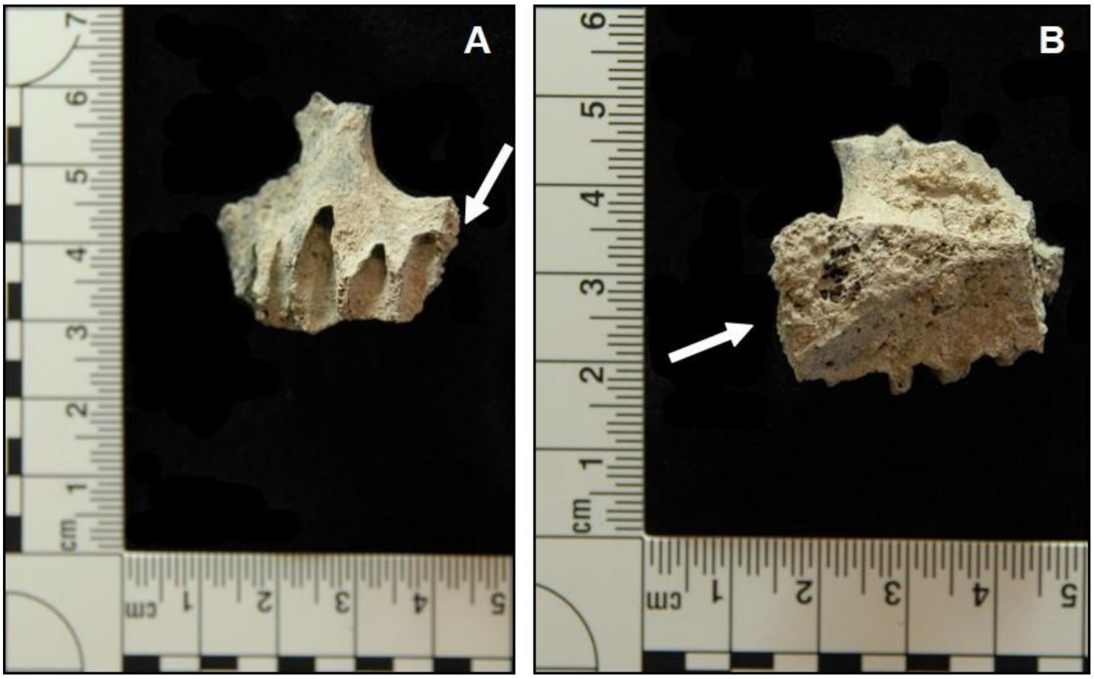


Figure 114: Burial 110, (4203_H_L8), anterior right maxillary fragment, exhibiting very straight, oblique fracture through central right maxilla and palate with stained fracture surface, suggesting deeply penetrating, oblique sharp force cut across centre of face.

Figure 115: Burial 110, (4180_Quad-B), anterior mandibular fragment, inferior view showing polished cut surface and breakaway wall (white arrow), evidencing moderate oblique cut to inferior aspect of individual's chin.

Figure 116: Burial 110, (4180_Quad-B), posterior right mandibular fragment, lateral view showing polished cut surface to posterior margin of ascending ramus (white arrow), evidencing moderate oblique cut to posterior aspect of individual's right lower jaw; Note the fractures to the superior ramus and base of coronoid process, possibly indicative of blunt force trauma to this region also.

Figure 117: Burial 110, (4180_Quad-B), anterior mandible exhibiting well defined breakage to superior aspect, possibly indicative of heavy peri-mortem blunt force trauma to the area of the mouth. Note adhering fragments and stained fracture surfaces.

Figure 118: Burial 110, (4180_QuadB), left mandibular fragment, exhibiting inverted V-shaped incision to anterior lateral surface of condylar neck (white arrow), possibly representing sharp force trauma to the region of the left cheek.

Figure 119: A) Burial 110, (4278_A_L9), right mandibular condyle, exhibiting oblique fracture just below condylar neck, with slightly curving fracture outline and 'polished' flat, stained fracture surface, indicating probable sharp force trauma; B) Burial 110, (4180_QuadD), spinous process fragment of cervical vertebra exhibiting oblique linear incision across superior surface. This fragment also exhibited a very flat fracture surface across the extant inferior aspect of the spinous process suggestive of a second, heavier sharp force cut to the neck.

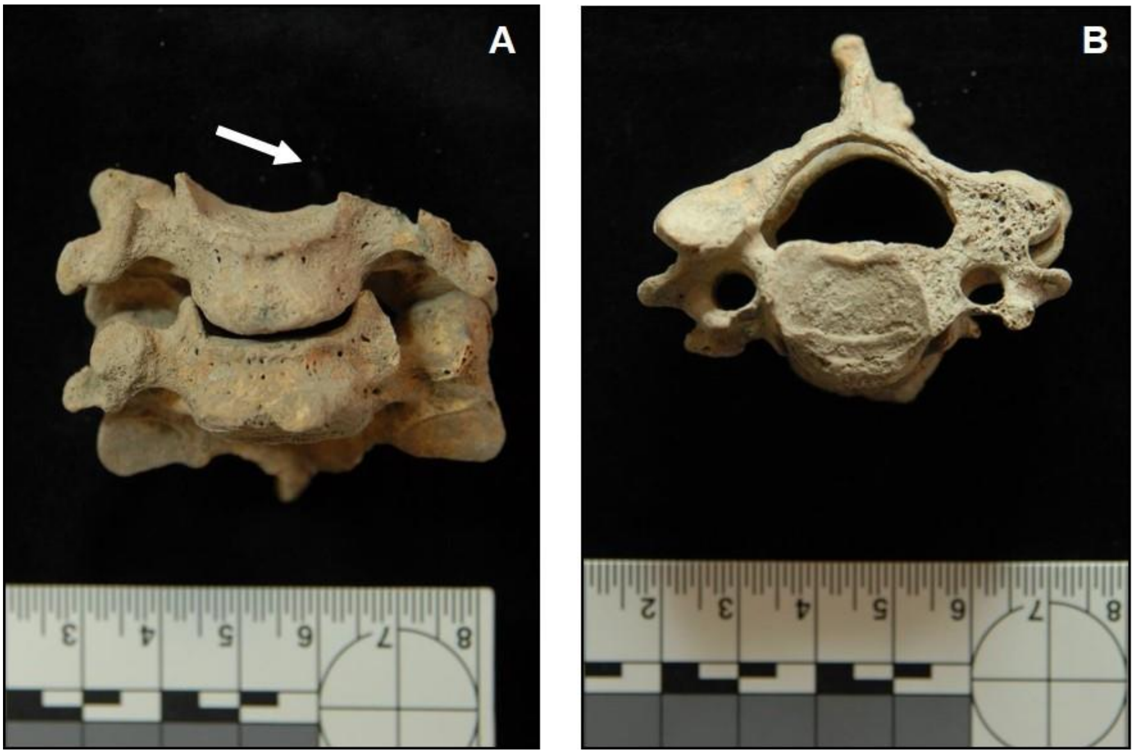


Figure 120: Burial, (4180_QuadB), two cervical vertebrae, found articulated in situ, with the upper vertebra exhibiting a slightly oblique fracture across the left apophysis, with loss of the superior articular facet and the left uncinate process, indicating a sharp force cut affecting the left side of the neck at least. A) Anterior view; B) Superior view.

Figure 121: Burial 110, (4180_QuadD), right scapular fragment exhibiting 'polished' cut surface to lateral root of acromion, with slightly curving fracture outline, 'polished' and stained fracture surface and sharp fracture edges, indicative of definite sharp force trauma to right shoulder of the individual. Note the roughened surface at the base of the lesion (white arrow), indicative of 'bone tear', probably occurring as the blade was removed.

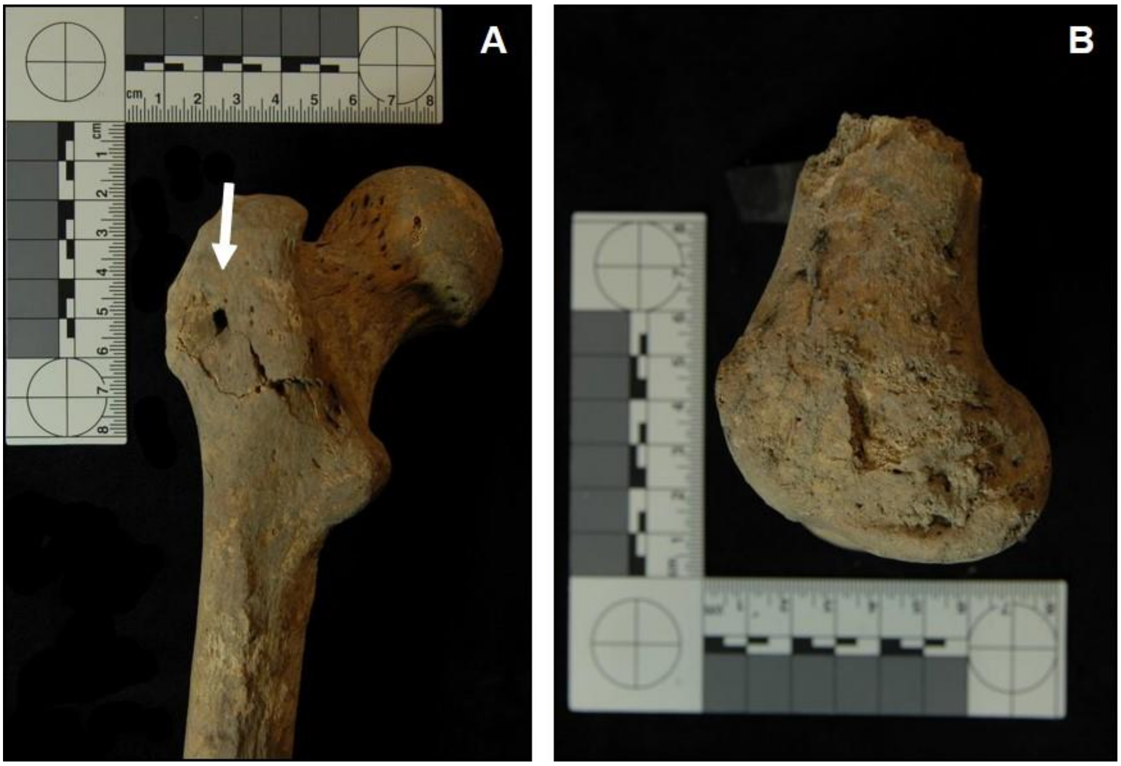


Figure 122: Femoral lesions – A) Burial 110, 4311, proximal left femur exhibiting well-defined perforation to the posterior aspect of the greater trochanter, indicating peri-mortem penetrating trauma, possibly representing either projectile trauma, a stabbing injury. Note the associated incomplete fracturing and depression, indicative of blunt force trauma and probably associated with the same impact as the penetrating lesion; B) 4284, distal left femoral fragment exhibiting well-defined, right-angled depression to region of lateral epicondyle, suggestive of shaped peri-mortem blunt force trauma to the outside of the individual's left knee.

APPENDIX A10: Fracture characteristics

Table 53: Characteristics of peri-mortem fractures (not commonly seen on dead/dry/non-elastic cranium).

Reported peri-mortem characteristics	**Reference(s)**
Concentric circular fracture lines	Lovell (1997: 145); Maples (1986: 221)
Radiating fracture lines	Lovell (1997: 145); Maples (1986: 221)
Stellate fracture pattern	Lovell (1997: 145); Maples (1986: 221); Moraitis et al. (2008)
Linear cut marks, sharp-edged, raised margin	
'Percussion damage'	Blumenschine (1995); Villa and Mahieu (1991)
Spiral fracture line	Lovell (1997: 145)
Greenstick fractures	Lovell (1997: 145)
Incomplete fractures	Lovell (1997: 145)
Depressed/ Compressed fractures	Lovell (1997: 145)
Curving fracture line	Villa and Mahieu (1991: 43)
Jagged fracture	Moraitis et al. (2008)
'Butterfly' fracture	Galloway (1999); Moraitis et al. (2008); Wedel and Galloway (2014)
Plastic deformation	Moraitis et al. (2008)
Hinged/adherent fragments	Ortner (2003); Moraitis et al. (2008)
Smooth cortical fracture margins	Johnson (1985); Quatrehomme and İşcan (1997); Villa and Mahieu (1991);
Oblique fracture angles	Lovell,1997: 145;
Fragments with 'twisted profile'	Villa and Mahieu (1991: 37n)
'hackle marks'/ Small fissures (occurring near impact site, parallel with fracture margin, not necessarily fully- penetrating cortical bone)	Bonnichsen and Will (1990); Johnson (1985: 161, fig. 5.1)
'Wedge-flaking'	Johnson (1985: 179, fig. 5.6);
Associated 'bone peeling'	Moraitis and Spiliopoulou (2006);
Associated 'bone tear'	Moraitis and Spiliopoulou (2006); Moraitis et al. (2008)
Breakaway 'notch'	Moraitis et al. (2008)
Non-differentiated fracture surface colouring	Lovell (1997: 145); Moraitis and Spiliopoulou (2006)

Table 54: Typical defects attributed to post-mortem alterations and associated locations (N.B. This table contains indicative data and represents current knowledge in flux).

Reported post-mortem defects	Location	Category	Typical Cause
Parallel grooves (usually sets, often fan-shaped sets)	Orbital margins, fracture margins	Animal scavenging	Rodent gnawing
Irregular fracturing and loss	Long bone ends	Animal scavenging	Carnivore scavenging
Small puncture holes		Animal scavenging	Carnivore scavenging
Crenellation	Iliac crests	Animal scavenging	Carnivore scavenging
Fractures with cavitation	(exposed) extremities e.g. calcanei, metacarpal/ metatarsal heads	Animal scavenging	Rodent gnawing/ carnivore scavenging
Small, triangular fractures	Orbital surfaces	Bird scavenging	Vulture/raptor scavenging
Stellate fracture patterning across curved surfaces	Cranial vault	Weathering	Combination of sun- bleaching and freeze/ thaw cycles
Cortical flaking		Weathering	
Cortical cracking		Weathering	
Stepped fractures			
Split-line interference		Weathering	
Transverse fracture line	Long bone diaphyses		
Irregular/jagged fracture line			
Granulated/ roughened cortical fracture margins			
Perpendicular fracture angle	Long bone diaphyses		
Non-uniform colouration of fracture surfaces and adjacent bone surface			
Absence of fracture patterning (due to increased tendency of dry, brittle bone to shatter on impact)			

APPENDIX A11: Isotopic Methods

Strontium and Oxygen Isotope Analyses

Destructive Sampling

As Montgomery (2002: 128) points out, attitudes to destructive analysis of human skeletal material vary widely in archaeology and the broader heritage sector. Following the Alder Hey scandal (Redfern, 2001) and the subsequent passing of the Human Tissue Act (2004), the ethics of scientific research of human remains came under close scrutiny. As a direct consequence, several stakeholder institutions have issued guidance concerning research on human skeletal remains (English Heritage, APABE and The Church of England, 2005; DCMS, 2005; APABE, Historic England and The Church of England, 2017) including specific publications concerning destructive sampling (English Heritage and APABE, 2008).

The main concern with destructive sampling is the potential need for the specific bone for future research, for example the application of either a current technique or new or emerging techniques as yet not applied or undeveloped at present.

However, with care, a small, but sufficient amount of enamel (c.20-45mg) can be obtained from a single molar tooth, with damage typically limited to one quarter of a permanent molar crown for Sr and O analyses, under specific conditions i.e. attritional wear is minimal and enamel preservation is good enough to undergo mechanical cleaning.

Similarly, a small amount of cortical bone (c.0.5 – 2g) can be sampled from either/both rib and long bone shaft sections, with damage typically limited to less than one quarter of a rib and less than 10% of a long bone diaphysis for carbon and nitrogen analyses, under specific conditions i.e. post-mortem damage is minimal and bone preservation is good enough to undergo mechanical sectioning and cleaning.

Sample selection criteria

The type and position of tooth was standardised across all samples wherever possible. In order to maximise the sample size, the right third molar (T48, N = 8) was selected as it represented the greatest number of teeth which could be attributed to separate individuals, given the limited articulation of incomplete individuals within both burials 101 and 110. In addition, a single right second molar (T47, N = 1) was also sampled as its association with the mandibular fragment from which it derived, meant it could be differentiated from the initial eight individuals.

The main consideration during sample selection was whether enough enamel was available in the third molars to provide a quantity sufficient and appropriate for analysis (taking into account the loss of material during cleaning) and whether the preservation state would permit mechanical cleaning. As a result, teeth that clearly exhibited obvious poor preservation, severe wear or physical damage were not deliberately selected, but were included in order to maximise sample size.

Factors considered when selecting samples followed Montgomery (2002: 127):

- Prospective enamel yield
- Time of formation. To ensure teeth had been formed from the diet of the child, rather than the diet of the mother (either in utero or during breastfeeding), a tooth forming post-weaning was preferred.
- Variability of formation times. The variability of individual tooth formation times can vary dramatically with different teeth and between the sexes (e.g. Ubelaker, 1989: 64)

Limiting factors affecting tooth choice and sample selection included:

- Antemortem tooth loss
- Post-mortem tooth loss
- Tooth wear and/or pathology (e.g. caries)
- Evidence of heat alteration

Teeth chosen were intact, excepting normal attrition and the majority were free from premortem dental modifications.

N.B. One sample exhibited a defect to the base of the crown which may have been antemortem or peri-mortem; alternatively, this defect represents old post-mortem damage.

The analytical procedure is destructive and this naturally had a bearing on the nature of samples preferred for analysis.

Samples analysed

All samples were sourced from human tooth enamel from individualised elements deriving from the mass grave deposits known as burials 101 and 110, excavated at College Site, Sidon, Lebanon. A list of the samples analysed and their contexts is provided in Table A.

In addition, a c. 10 mg sample of crown dentine was obtained from two teeth (SIDN101-1 (Torso C) and SIDN110-5 (from Quad B (4180)) to assess labile soil strontium in the absence of environmental or biosphere data (e.g. see Montgomery et al. 2007).

Prior to sampling, all teeth had previously been subject to minimal cleaning to remove the majority of any adhering sediment.

Sample pre-treatment

A secondary aim of the study was to investigate the post-mortem isotope integrity of the dentine in comparison to the tooth enamel. In this regard, pre-treatment procedures (such as acid leaching or solubility profiling) were deliberately not applied.

Following Montgomery (2002: 129), physical removal of age-affected tissues (i.e. surface enamel and circumpulpal, root and secondary dentine), via mechanical cleaning, was undertaken to limit final samples to primary core enamel or dentine.

Samples of core enamel were then subsampled for separate strontium and oxygen analyses.

Powdering of enamel subsamples was carried out at the class 100 HEPA-filtered laboratory facility at Durham University, prior to the subsamples being transferred in sealed containers to the Stable Isotope Laboratory, University of Bradford, UK for oxygen isotope analysis.

For oxygen and carbon isotope determination of structural carbonate powdered enamel samples were treated with 1.7% NaOCl solution for 30 min to remove organic matter and rinsed with distilled water, before adding 0.1M acetic acid for 10 min to remove exogenous carbonate following a protocol modified after Sponheimer (1999).

Method

Following initial selection of gross skeletal and dental elements at Bournemouth University, sampling of tooth enamel from the eight individualised mandibular M3s and one mandibular M2 took place at the Department of Archaeology, Durham University, Durham, UK.

The individual teeth were macroscopically analysed for evidence of any pathology and photographed in the occlusal, buccal, lingual, mesial and distal aspects prior to sample preparation.

Sections of core enamel were extracted in the Sample Preparation Laboratory in the Department of Archaeology, Durham University.

Processed chips of tooth enamel were then sealed in Eppendorf microtubes and transferred to the (class 100, HEPA-filtered) laboratory facilities at Durham for further preparation.

Tooth sample preparation

Tooth sample preparation followed the guidelines according to Montgomery (2002). Enamel was sectioned using a diamond-edged dental saw. Subsequently, all surface enamel was mechanically removed along with any dentine still adhering using a tungsten carbide burr.

After cleaning, samples were weighed in order to record yield.

Dental tools

Two tungsten carbide burrs (DFS, Riedenberg, Germany) were employed to extract the required samples.

“Tungsten carbide is an extremely hard material which introduces negligible Pb and Sr contamination (unlike agate which can introduce Sr and up to 18ppm Pb) (Royse et al. 1998: 3)”. Tungsten carbide is recommended for grinding low-concentration geological samples prior to Pb and Sr analyses and so is well suited to the sampling of enamel.

No suitable tungsten carbide rotary saw is currently available and consequently a flexible, clean stainless steel saw with a diamond-coated cutting edge was used for initial sectioning of teeth samples.

All saw cut surfaces and the extant surface enamel of sectioned samples were subsequently cleaned using a clean tungsten carbide burr.

Dental tools were cleaned prior to use and between every sample following a slightly modified version of Montgomery's (2002: 132) procedure:

1. Rinsed in Millipore Alpha Q H_2O
2. Ultrasonicated for 5 minutes in Millipore Alpha Q H_2O
3. Rinsed in Millipore Alpha Q H_2O
4. Ultrasonicated for 5 minutes in Millipore Alpha Q H_2O
5. Rinsed in Millipore Alpha Q H_2O

Tooth dissection

The outer surface of the enamel was removed to a depth of c.100µm using a clean tungsten carbide burr to remove any discoloured or visibly damaged areas of enamel and the surface enamel itself. Removal of surface enamel helped to minimise the risk of any potential contamination from the burial environment contributing to the analysis (Lee et al., 1999; Montgomery et al., 1999). Enamel samples were also rigorously cleaned of any adhering dentine and the enamel bordering the enamel dentine junction (EDJ). This procedure ensured that all samples consisted of 'core' enamel only and were free of both surface enamel and the heterogenous EDJ.

Montgomery (2002: 133) warns that this cleaning process is difficult to carry out systematically over the undulating surface of enamel tooth crowns. The process was monitored through the visual appearance of the cleaned enamel surface. Thus, following Montgomery's recommendation (2002: 133), areas of histological complexity (i.e. occlusal fissures) were avoided during sampling, not only due to the difficulty of cleaning them, but also because they are known to be potentially less well-mineralised and consequently subject to a greater likelihood of post-mortem contamination (Robinson et al., 1995b: 169, cited by Montgomery (2002: 133)).

In two cases, samples were obtained of tooth dentine in addition to the crown enamel samples.

If the samples intruded into the pulp cavity, this was also abraded using a tungsten carbide burr to remove any remaining organic matter or sediment if present along with circumpulpal and, if present, secondary dentine. This procedure ensured that all dentine samples were of primary crown dentine only, with no root or circumpulpal dentine contributing to the analysis.

All samples were sealed in clean, labelled containers and transferred to a class 100 HEPA-filtered cupboard for further preparation. Remaining unused material was retained for future use.

Analytical method: Strontium

For strontium, small, c. 5-15 mg samples of enamel were removed from the tooth crowns following the method of Montgomery (2002), whereby all surfaces were mechanically abraded with dental burrs to remove post-mortem contamination, surface enamel and all adhering dentine. In addition, a c. 10 mg sample of crown dentine was obtained from two teeth (SID101-1 (Torso C from B.101) and SIDN110-5 (from Quad B (4180))) to assess labile soil strontium in the absence of environmental or biosphere data (e.g. see Montgomery et al. 2007).

Prepared samples were sealed in microtubes and transferred to the clean laboratory facilities in the Department of Earth Sciences, Durham University and prepared for strontium isotope analysis using resin column chemistry methods outlined in Charlier et al. (2006).

1. Samples were heated on a hot plate for 20 minutes in 75 µl of 16M HNO3; the solution was then diluted with 325 µl of MQ H2O to make 3M HNO3 and heated overnight.
2. The samples were loaded onto cleaned and preconditioned columns containing 60 µl of Eichrom strontium-specific resin. 2x250 µl 3M HNO3 was eluted to remove the bulk of the matrix followed by 2x200 µl MQ H2O to elute the strontium, which was collected.
3. The Sr fraction was acidified with 17.5µl 16M HNO3 to prepare the samples for analysis using a Thermo Fisher Neptune Multi-Collector Inductively Coupled Plasma Mass Spectrometer (MS-ICP-MS).
4. The size of the 86Sr beam was tested for each sample to derive a dilution factor so that each sample yielded a beam size of approximately 20V 88Sr to match the intensity of the isotopic reference material, NBS987.

5. Samples were aspirated using an ESI PFA-50 nebuliser coupled with a glass expansion cinnabar micro-cyclonic spraychamber. Sr isotopes were measured using a static multi-collection routine with each measurement representing a single block of 50 cycles with each cycle being a 4 second integration (total analysis time ~3.5mins).
6. Instrumental mass bias was corrected for using a 88Sr/86Sr ratio of 8.375209 (the reciprocal of the 86Sr/88Sr ratio of 0.1194) and an exponential law. Corrections for interferences from Rb and Kr on 87Sr and 86Sr were performed using 85Rb and 83Kr as the monitor masses but in all cases the intensity of monitor mass was <0.1mV and therefore insignificant. The mean 87Sr/86Sr ratio and reproducibility for the international isotope reference material NBS987 during this study was 0.710250 ± 0.000009 (2σ; n=9).

Analytical method: Oxygen

For oxygen, small, c. 20-45 mg samples of enamel were removed from the tooth crowns following the method of Montgomery (2002), whereby all surfaces were mechanically abraded with dental burrs to remove post-mortem contamination, surface enamel and all adhering dentine.

Prepared samples were sealed in microtubes and transferred to the clean laboratory facilities in the Stable Isotope Laboratory, University of Bradford, UK.

Rinsed and freeze-dried samples were weighed in duplicate and isotopic compositions were measured using a Finnigan Gasbench II connected directly to a Thermo Delta V Advantage continuous flow isotope ratio mass spectrometer.

1. Enamel carbonate was reacted with anhydrous phosphoric acid at 70°C to release CO2 gas from which $\delta\ ^{18}O_{VSMOW}$ and $\delta\ ^{13}C_{VPDB}$ were determined using a CO2 reference gas.
2. Data were normalized by means of a linear calibration equation derived from a plot of accepted versus measured values for two internal standards, Merck Suprapur CaCO3 and OES (ostrich egg shell), and the NBS19 international standard. Analytical precision was ± 0.1 ‰ (1 SD) for carbon isotope ratios and ±0.2 ‰ (1 SD) for oxygen isotope ratios determined using an internal enamel laboratory standard.

3. The normalized carbonate $\delta^{18}O$ values were converted to phosphate values using equations by Chenery et al. (2012) and Iacumin et al. (1996) and then to drinking water values using equation 6 from Daux et al. (2008: 1143).

Carbon and nitrogen isotope analyses

Sample selection criteria

It was deemed valid to sample cortical bone collagen from both ribs and long bones in order to gain insight into potential dietary changes within the group over time.

The type and position of cortical bone sample was standardised across each group of samples where possible. In order to maximise the sample size, the following bone elements were chosen for sampling:

- Right 1st rib (N = 11)
- Lateral anterior aspect of the left proximal femur (N = 20)

Limiting factors affecting cortical bone choice and sample selection included:

- Antemortem trauma
- Post-mortem damage
- Peri-mortem or post-mortem evidence of burning
- Bone pathology

The analytical procedure is destructive and this naturally had a bearing on the nature of samples preferred for analysis.

Samples analysed

All samples were sourced from human remains deriving from the mass grave deposits known as burials 101 and 110, excavated at College Site, Sidon, Lebanon.

Sample pre-treatment

Following Ambrose's (1993: 72-) methodology, samples underwent several stages of pre-treatment and purification in order to remove potential contaminants such as lipids, biological carbonate in bone apatite, post-depositional carbonates, carbon and nitrogen in adhering sediments and other extraneous organic matter (such as plant rootlets, fungal hyphae, insect remains and humic and fluvic soil acids).

These purification stages included both mechanical and chemical pretreatment protocols, as outlined below:

Cortical bone sample preparation followed methods outlined in Ambrose (1993) and Brown et al. (1988).

Method

Following initial selection of gross skeletal elements at Bournemouth University, sample extraction and pre-treatment of cortical bone from the individualised human left femora (N = 20) and human right first ribs (N = 11) took place at the Department of Archaeology, Anthropology and Forensic Science, Bournemouth University, Bournemouth, Dorset, UK.

Sections of cortical bone were extracted in the Dorset House Laboratory in the Department of Archaeology, Anthropology and Forensic Science, Bournemouth University, following national guidelines on destructive sampling (English Heritage, 2013).

The individual bone elements were macroscopically analysed for evidence of any pathology and photographed in the anterior, posterior, medial, lateral, superior and inferior aspects prior to sample sectioning and pre-treatment. Any evident pathology, trauma or pseudotrauma was also photographed in detail prior to sampling.

Following preliminary removal of the majority of any adhering soil sediments using a brush, bone elements were sectioned using a rotary saw with diamond-coated cutting edge.

For the femoral samples, the size of the rotary saw used to section the cortical bone typically resulted in a sample larger than required. Consequently, all femoral shaft samples were sub-sampled, with excess material retained for potential future analyses.

Prior to mechanical abrasion, all sub-samples were weighed and their masses recorded.

Following sectioning and selection of the sub-sample to be analysed, all exposed surfaces of the subsample were mechanically abraded in order to remove bone which may have been subject to potential percolating contaminants. A SIMED Microjet Sandblaster chamber, in conjunction with aluminium oxide powder (graded), was used to lightly abrade the bone surfaces of the sub-sample, removing any discolouration or adhering sediment or soil particles until a fresh surface of consistent colour had been exposed across all surfaces.

Subsequent to mechanical abrasion, the sub-sample was weighed again and the mass recorded.

Subsamples were then subjected to a modified Longin method (Brown et al., 1988) for collagen extraction, outlined in detail below:

1. The sub-sample was lightly crushed within aluminium foil, using a pestle and mortar, so as to produce smaller, longitudinally-split fragments of cortical bone. This was done to facilitate the flow of acid around the mineral phase of the bone during the demineralisation stage of purification.

2. Following this, the sub-sample was placed inside a test tube and its final mass calculated. A 0.5M solution of Hydrochloric Acid (HCL) was then added to the test-tube using a pipette, so that the sub-sample was fully submerged in the solution.

   Aluminium foil was used to loosely cover the tops of the test-tubes. The sub-samples were then left in solution and refrigerated at a temperature between 4°C and 6°C, whilst demineralisation took place.

   Sub-samples were checked regularly and the acid solution replaced until no further reaction was observed or discolouration of the solution became evident.

   Once demineralisation was deemed to have been completed or discolouration of the solution was observed, the acid solution was removed using a pipette and replaced with deionised/distilled water.

   (**N.B.** Whilst demineralisation is typically expected to range between two and six weeks, many of the samples appeared to exceed this upper time period by a week or two. It's possible the HCL was weaker than expected or alternatively there was significantly more mineral material than preserved collagen, hence the eventual discolouration of the solutions despite the apparent continued presence of solid, hard mineral material)

3. The sub-samples were then gelatinised at 72°C for 48 hours in fresh deionised/distilled water, adjusted to ph 3, using c.3 drops of 0.5 HCL.
4. Following gelatinization, the extraction mix was filtered using Ezee filters (Elkay Laboratory Products, Basingstoke, UK) to remove insoluble materials.
5. The filtrates were decanted into fresh test tubes, sealed with pierced parafilm and placed at 45° within a freezer.
6. Frozen filtrates were subsequently freeze-dried prior to analysis using a mass spectrometer.

Analytical Method

The initial pilot study to test for the potential for sequential analyses of tooth dentine was carried out at the University of Bradford by Dr Julia Beaumont following standard analytical methods.

Radiocarbon isotope analysis and dating

Sample selection criteria

The main motive for additional radiocarbon dates (in addition to the original date obtained in 2009), was to confirm that burial 101 was contemporary with burial 110. Secondary to this, it was thought that additional dates could potentially permit the date of the deposits to be narrowed down further, applying Bayesian principles as outlined by Millard (2015).

Samples analysed

All samples were sourced from human remains deriving from the mass grave deposits known as burials 101 and 110, excavated at College Site, Sidon, Lebanon.

Samples were sealed in bags and transferred to the clean laboratory facilities at

^{14}Chrono Centre, Queen’s university, Belfast for radiocarbon isotope analysis using accelerated mass spectrometry (AMS).

Method

Analytical Method

Sample pre-treatment and analysis was carried out at 14Chrono Centre, Queen’s University, Belfast and followed established laboratory protocols as detailed in Reimer et al. (2017).

$\delta^{13}C$ was measured on the AMS for fractionation correction of the radiocarbon age (see Appendix 8).

Calibration and statistical interpretation

Calibration was carried out using the Calib software (Stuiver et al., 2005; 2019), with reference to the IntCal13 calibration curve (Reimer et al., 2013).

T-test statistical analyses were carried out using the Calib software which follows Ward and Wilson (1978).

APPENDIX A12: Isotope Sample Weights

Table 55: Strontium sample materials and weights from Sidon crusader-period human remains.

Sample ID	Material	Tooth Element	Sample Weight (mg)
SIDN101-1	Human tooth enamel	T48	12.5
SIDN110-1	Human tooth enamel	T48	13.6
SIDN110-2	Human tooth enamel	T48	9.6
SIDN110-3	Human tooth enamel	T48	13.5
SIDN110-4	Human tooth enamel	T48	12.3
SIDN110-5	Human tooth enamel	T47	5.1
SIDN110-6	Human tooth enamel	T48	5.8
SIDN110-7	Human tooth enamel	T48	8.7
SIDN110-8	Human tooth enamel	T48	5.5
SIDN110-1D	Human tooth dentine	T48	9.4
SIDN110-5D	Human tooth dentine	T47	7.5

Table 56: Oxygen sample materials and weights from Sidon crusader-period human remains.

Sample ID	Material	Tooth Element	Sample Weight (mg)
SIDN101-1	Human tooth enamel	T48	36.9
SIDN110-1	Human tooth enamel	T48	28.2
SIDN110-2	Human tooth enamel	T48	42.1
SIDN110-3	Human tooth enamel	T48	18.0
SIDN110-4	Human tooth enamel	T48	30.2
SIDN110-5	Human tooth enamel	T47	20.0
SIDN110-6	Human tooth enamel	T48	21.3
SIDN110-7	Human tooth enamel	T48	30.0
SIDN110-8	Human tooth enamel	T48	30.3

N.B. Oxygen sample for B.101 (4147) Torso C recorded in lab book = 52.2mg

Table 57: Radiocarbon sample materials and weights from Sidon crusader-period human remains (data for Sanger samples not included).

Sample ID	Material	Tooth Element	Sample Weight (g)
SIDN101-3	Human tooth dentine	T36	0.500
SIDN101-4	Human tooth dentine	T38	0.391
SIDN110-11	Human tooth dentine	T46	0.628
SIDN110-12	Human tooth dentine	T48	0.283

Table 58: Carbon/nitrogen sample materials and weights from Sidon crusader-period human remains.

Sample ID	Material	Bone/ Tooth Element	Sample Weight (pre-cleaning) (g)	Sample Weight (post-cleaning) (g)
SIDN110-5Seq	Human dentine	T47	n/a	0.140
SIDN101-5	Human bone	L. Femur	1.160	1.124
SIDN101-6	Human bone	L. Femur	1.465	1.409
SIDN101-7	Human bone	L. Femur	0.990	0.945
SIDN101-8	Human bone	L. Femur	1.390	1.337
SIDN101-9	Human bone	L. Femur	1.430	1.340
SIDN101-10	Human bone	L. Femur	1.309	1.237
SIDN101-11	Human bone	R. 1st Rib		0.982
SIDN110-14	Human bone	L. Femur	1.090	1.061
SIDN110-15	Human bone	L. Femur	1.090	1.195
SIDN110-16	Human bone	L. Femur	1.310	1.244
SIDN110-17	Human bone	L. Femur	0.975	0.937
SIDN110-18	Human bone	L. Femur	1.095	1.008
SIDN110-19	Human bone	L. Femur	1.380	1.349
SIDN110-20	Human bone	L. Femur	1.090	1.027
SIDN110-21	Human bone	L. Femur	1.415	1.336

SIDN110-22	Human bone	L. Femur	1.180	1.137
SIDN110-23	Human bone	L. Femur	1.270	1.203
SIDN110-24	Human bone	L. Femur	0.940	0.904
SIDN110-25	Human bone	L. Femur	1.220	1.090
SIDN110-26	Human bone	L. Femur	1.360	1.292
SIDN110-27	Human bone	L. Femur	1.215	1.171
SIDN110-28	Human bone	R. 1st Rib	1.390	1.276
SIDN110-29	Human bone	R. 1st Rib	1.300	1.213
SIDN110-30	Human bone	R. 1st Rib	0.930	0.873
SIDN110-31	Human bone	R. 1st Rib	1.050	0.945
SIDN110-32	Human bone	R. 1st Rib	1.370	1.251
SIDN110-33	Human bone	R. 1st Rib	1.210	1.159
SIDN110-34	Human bone	R. 1st Rib	0.985	0.933
SIDN110-35	Human bone	R. 1st Rib	0.765	0.726
SIDN110-36	Human bone	R. 1st Rib	1.110	1.018
SIDN110-37	Human bone	R. 1st Rib	0.940	0.864
SIDN4177-01	Animal bone	R. Rib	2.576	2.308
SIDN4177-02	Animal bone	R? Rib	1.274	1.137

APPENDIX A13: Radiocarbon Dating

Table 59: Summary of all radiocarbon date ranges produced from deposits within the Medieval fortification ditch at College Site, Sidon.

Laboratory Code	Burial No./ Context	^{14}C age yr BP	95.4% (2δ) Cal age ranges	Relative area under distribution	Calibration data	Publication Reference
OxA-22375	110	844±44	Cal AD 1160-1256		Bronk Ramsey (2010); Reimer et al. (2009)	Collins, 2012: 418, Fig.2
OxA-32121		820±24	Cal AD 1170-1263			Doumet-Serhal, 2016: 10, Fig.5a
UBA-33257[1]	101	821±35	Cal AD 1161-1269	1.000	Reimer et al., 2013	
UBA-33258[1]	101	927±28	Cal AD 1028-1164	1.000	Reimer et al., 2013	
UBA-33259[1]	110	857±30	Cal AD 1050-1082	0.084	Reimer et al., 2013	
			Cal AD 1127-1135	0.014	Reimer et al., 2013	
			Cal AD 1151-1257	0.902	Reimer et al., 2013	
UBA-33260[1]	110	634±37	Cal AD 1285-1399	1.000	Reimer et al., 2013	
UBA-36839[2]	110	780±35	Cal AD 1191-1283	1.000	Reimer et al., 2013	
UBA-36840[2]	110	812±22	Cal AD 1187-1266	1.000	Reimer et al., 2013	
UBA-36841[2]	110	774±27	Cal AD 1219-1278	1.000	Reimer et al., 2013	
UBA-36842[2]	110	811±45	Cal AD 1058-1075	0.016	Reimer et al., 2013	
			Cal AD 1154-1281	0.984	Reimer et al., 2013	
UBA-36845[2]	In layer (10143)	949±29	Cal AD 1025-1154	1.000	Reimer et al., 2013	

[1]Analysis kindly funded by The Gerard Averay Wainwright Fund (Research Grant AM/16)

[2]Data provided courtesy of Dr Marc Haber, funded by Wellcome Sanger Institute

Table 60: Summary of references and descriptions for radiocarbon dating samples collected and analysed contributing to the current study.

Laboratory Code	Sample ID	Burial No.	Context	Material	Bone/ Tooth Element
UBA-33257[1]	SIDN101-3	101	4147 (Torso C)	Human tooth dentine	T36
UBA-33258[1]	SIDN101-4	101	4147 (Torso C)	Human tooth dentine	T38
UBA-33259[1]	SIDN101-11	110	4203_H_L6	Human tooth dentine	T46
UBA-33260[1]	SIDN101-12	110	4203_H_L6	Human tooth dentine	T48
UBA-36839[2]	4247	110	4247	Human bone	Cranial (R. Parietal)
UBA-36840[2]	4271	110	4271	Human bone	Cranial (R. Parietal)
UBA-36841[2]	4301	110	4301	Human bone	Cranial (R. Parietal)
UBA-36842[2]	4304	110	4304	Human tooth dentine	T26
UBA-36845[2]	SI-53	In layer (10143)	10153	Human bone	Cranial (Petrous)

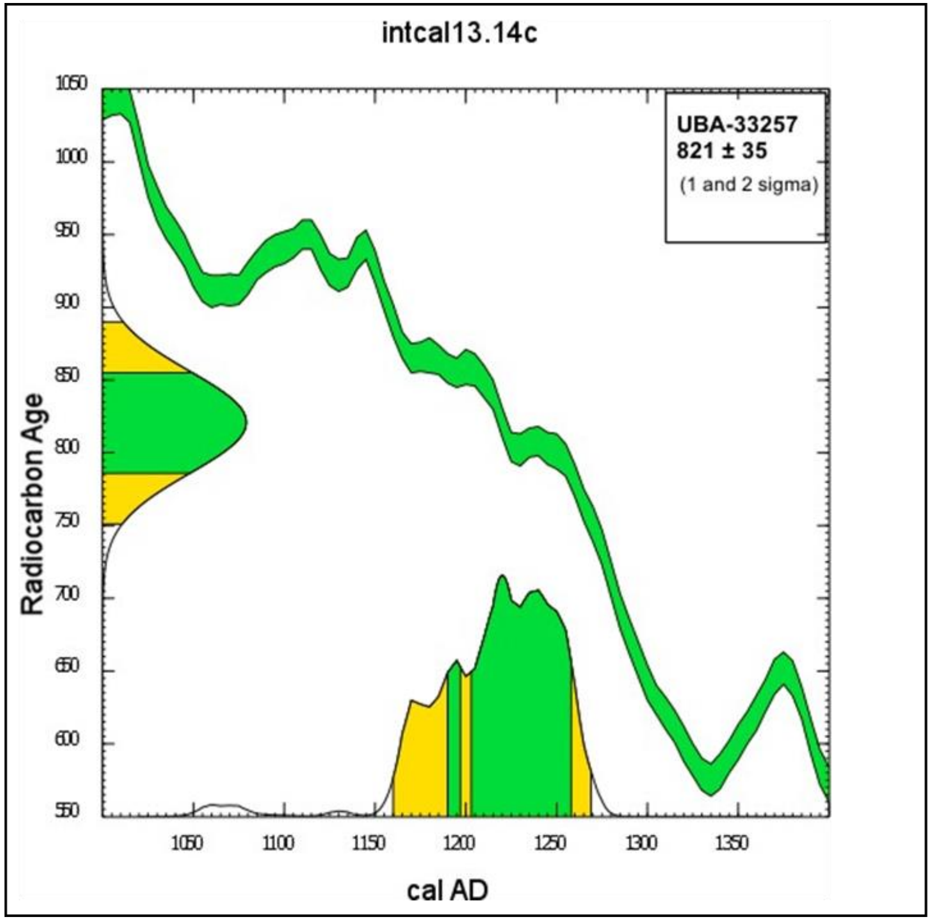
[1]Analysis kindly funded by The Gerard Averay Wainwright Fund (Research Grant AM/16)

[2]Data provided courtesy of Dr Marc Haber, funded by Wellcome Sanger Institute

Table 61: Summary of references and descriptions for previously reported radiocarbon dating samples.

Laboratory Code	Sample ID	Burial No.	Context	Material	Bone/Tooth Element
OxA-22375*		110	4180	Human bone	Femur (proximal)
OxA-32121*				Animal (bone?)	

*See Table 59 for references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UBA-33257
821 ± 35
(1 and 2 sigma)
Radiocarbon Age
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1000
950
900
850
800
750
700
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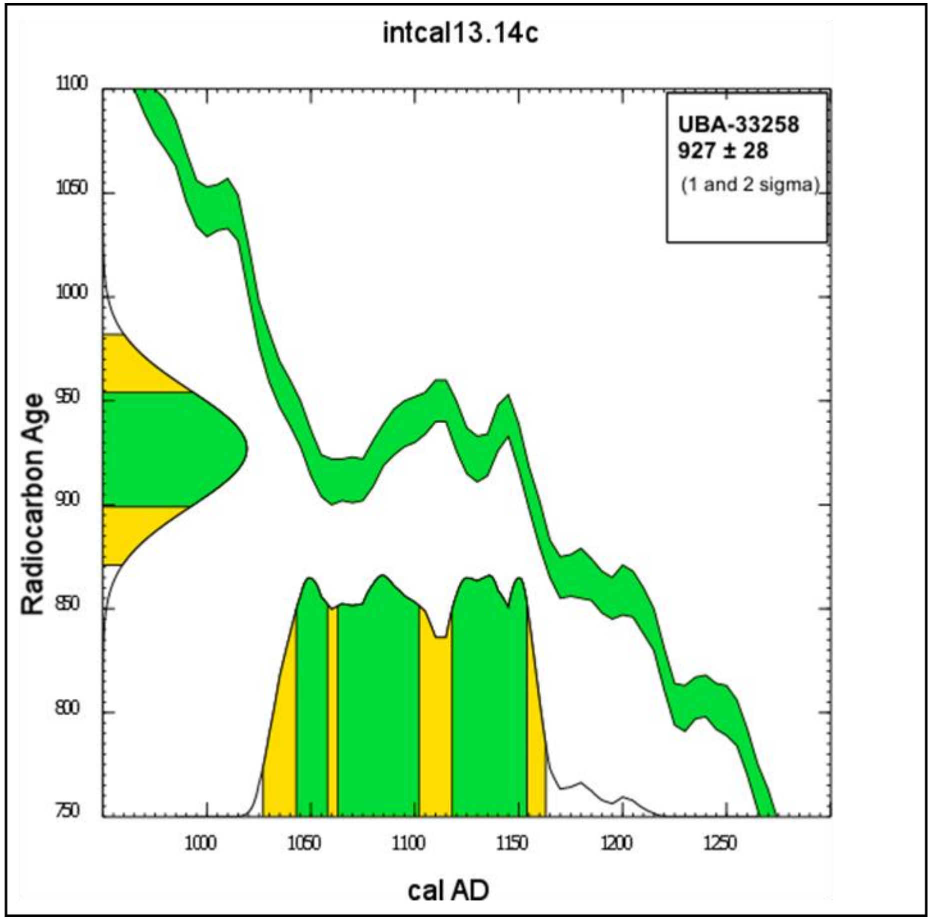
600
550
1050
1100
1150
1200
1250
1300
1350
cal AD


intcal13.14c
UBA-33258
927 ± 28
(1 and 2 sigma)
Radiocarbon Age
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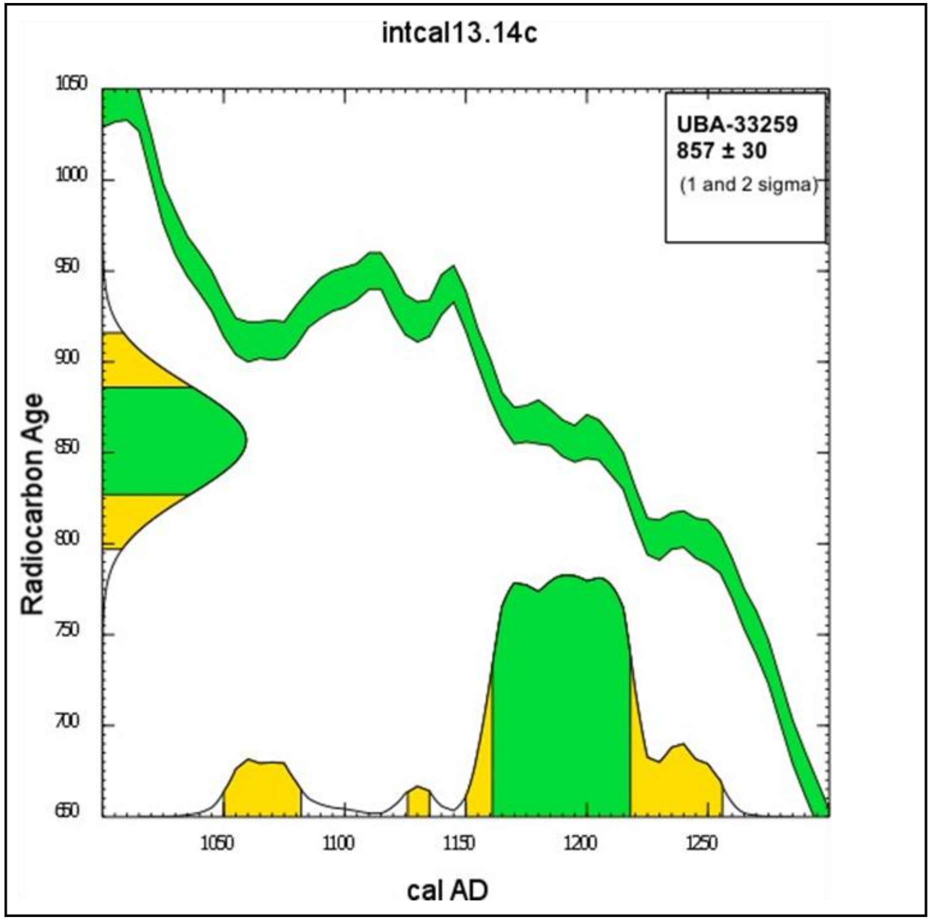
1050
1000
950
900
850
800
750
1000
1050
1100
1150
1200
1250
cal AD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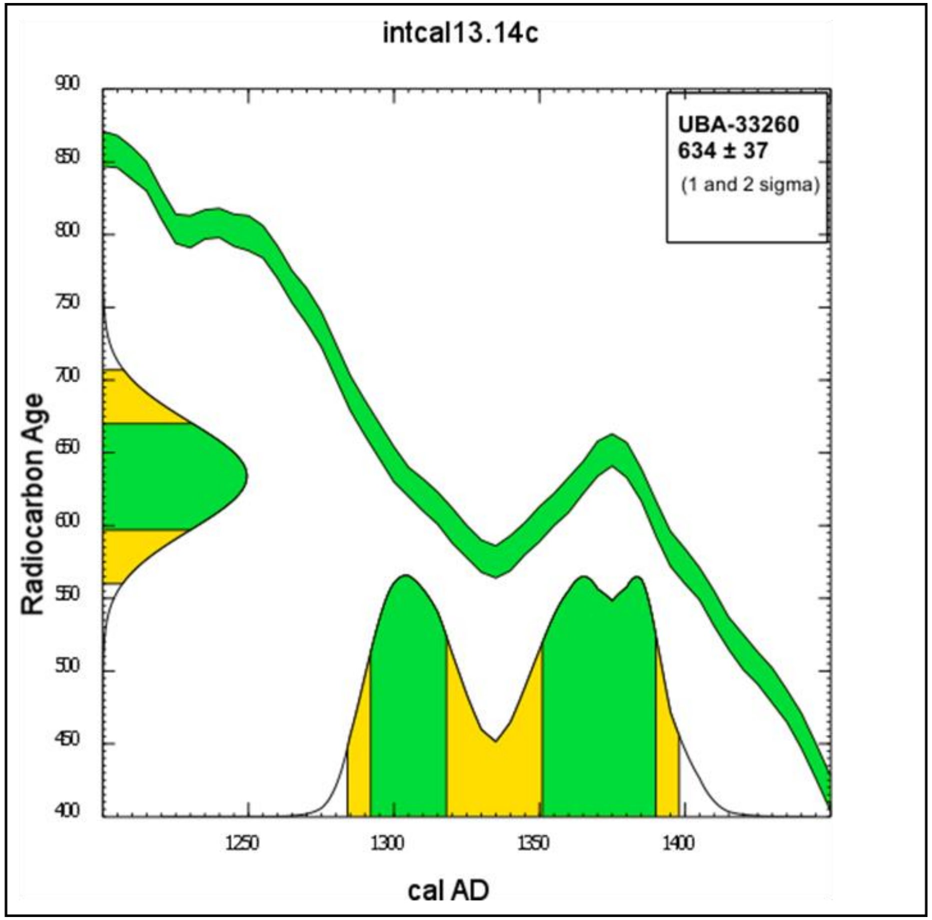
UBA-33259
857 ± 30
(1 and 2 sigma)
Radiocarbon Age
cal AD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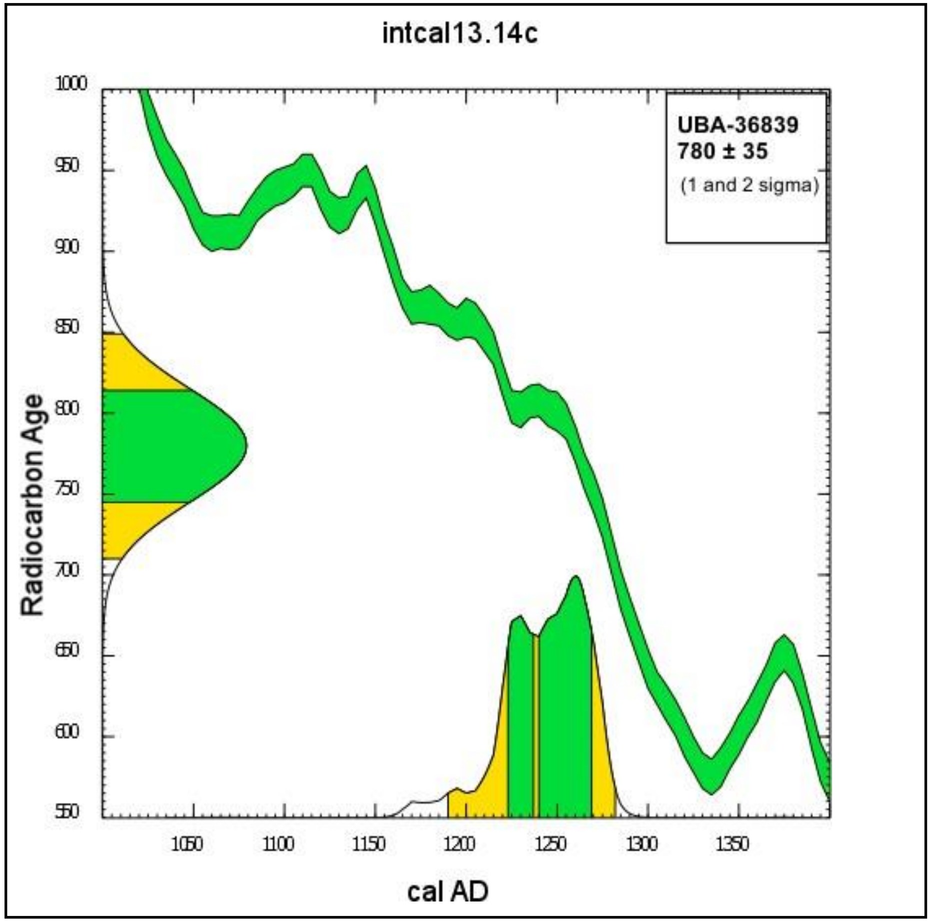
UBA-33260
634 ± 37
(1 and 2 sigma)
Radiocarbon Age
cal AD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UBA-36839
780 ± 35
(1 and 2 sigma)
Radiocarbon Age
1000
950
900
850
800
750
700
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600
550
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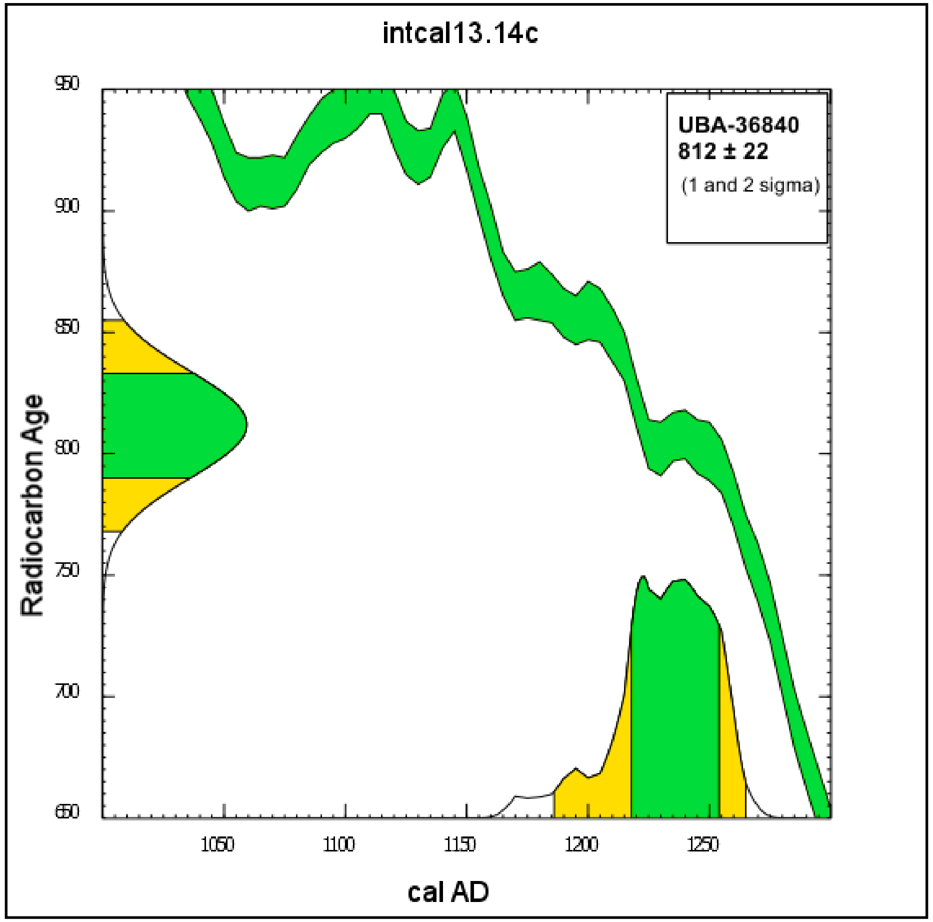
1100
1150
1200
1250
1300
1350
cal AD


intcal13.14c
UBA-36840
812 ± 22
(1 and 2 sigma)
Radiocarbon Age
950
900
850
800
750
700
650
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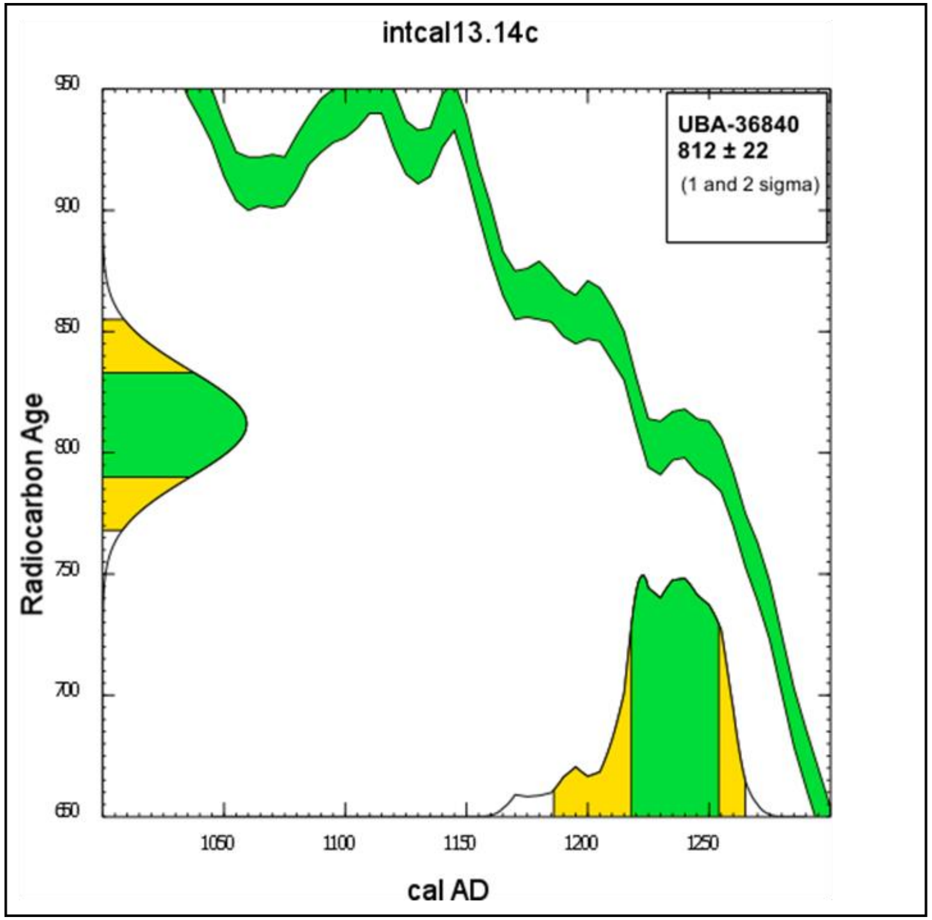
1100
1150
1200
1250
cal AD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UBA-36840
812 ± 22
(1 and 2 sigma)
Radiocarbon Age
950
900
850
800
750
700
650
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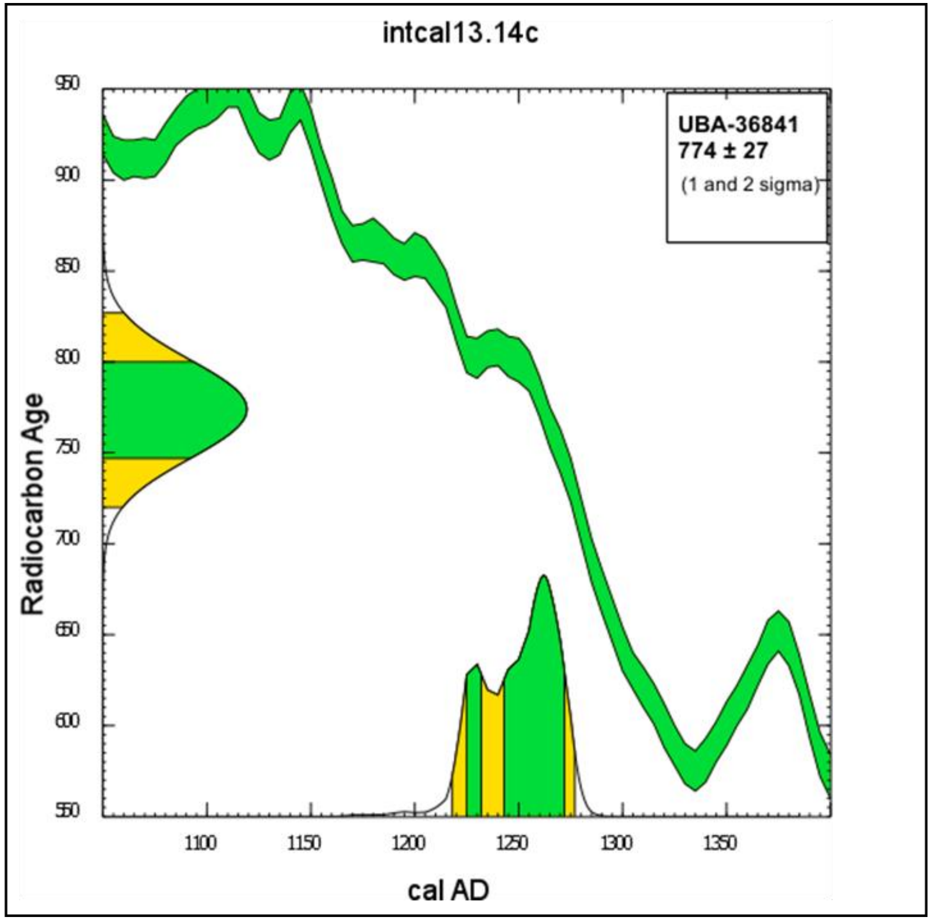
1150
1200
1250
cal AD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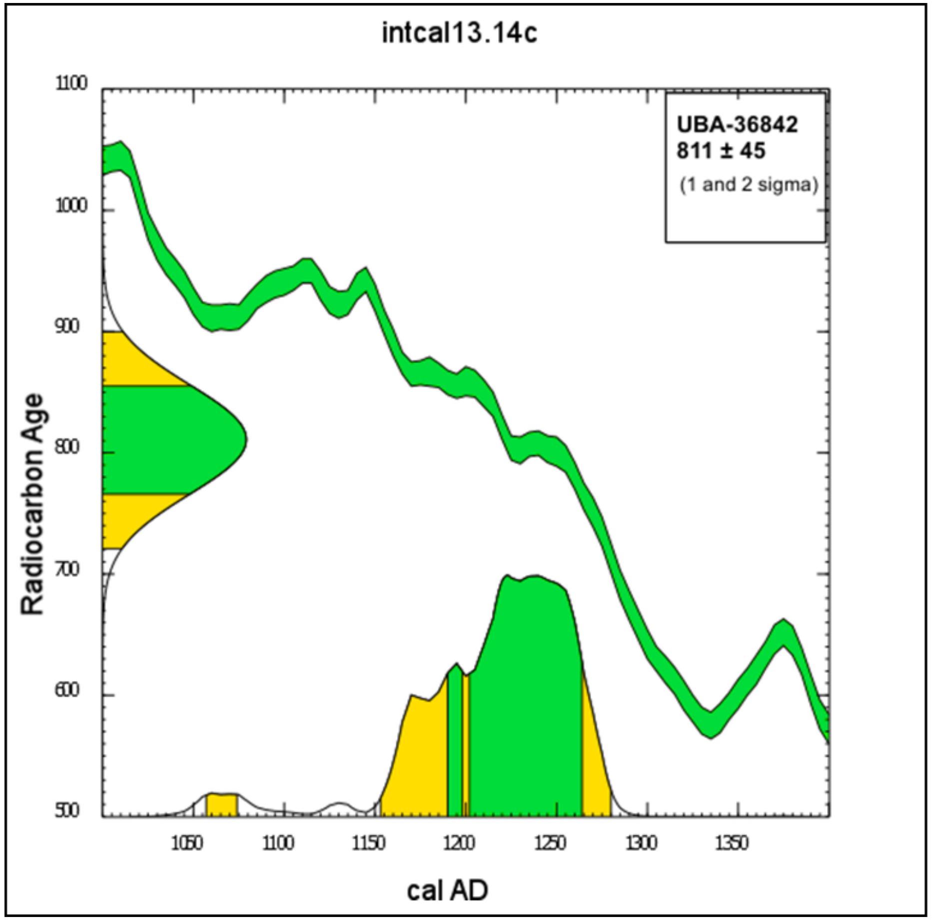
UBA-36841
774 ± 27
(1 and 2 sigma)
Radiocarbon Age
950
900
850
800
750
700
650
600
550
1100
1150
1200
1250
1300
1350
cal AD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UBA-36842
811 ± 45
(1 and 2 sigma)
Radiocarbon Age
1100
1000
900
800
700
600
500
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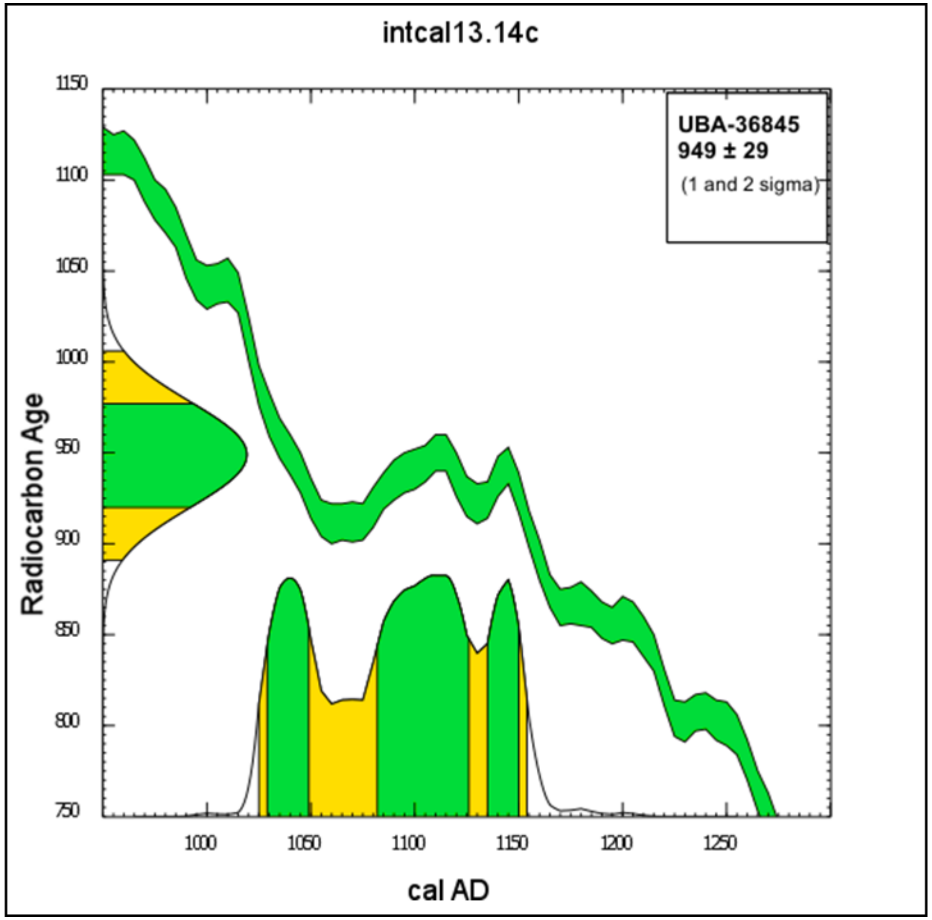
1100
1150
1200
1250
1300
1350
cal AD


intcal13.14c
UBA-36845
949 ± 29
(1 and 2 sigma)
Radiocarbon Age
1150
1100
1050
1000
950
900
850
800
750
1000
1050
1100
1150
1200
1250
cal AD

APPENDIX A14: Osteological Terminology Glossary

Abduct	To draw away from the midline (e.g. raising the arms).
Abrasion	The wearing away of a structure (e.g. a tooth).
Abscess	A localised collection of pus in a confined space.
Acromioclavicular	The joint between the collar bone and the shoulder blade.
Acromion	The lateral extension or 'wing' of the spine of the shoulder blade (scapula) – projects over the shoulder joint.
Adduction	To draw towards the midline (e.g. lowering the arms).
Aetiology	The factors causing a disease.
Agenesis	Absence of an organ, e.g. as a result of embryonic development.
Alveolar bone	The bone immediately surrounding the teeth.
Anisotropic	A characteristic of a material that has different mechanical properties when loaded in different direction due to its directional structure.
Antemortem	An event which occurred prior to death.
Anterior	Situated in/on the front of the body.
Anthropometric	Measurement of the size, weight and proportions of the human body.
Appendicular	Referring to the appendages of the skeleton, specifically the upper and lower limbs.
Articular	Relating to a joint.
Attrition	Accumulated wear on the teeth in the course of normal use.
Auricular	The ear-shaped articular surface of the ilium for the sacro-iliac joint.
Avulsion	The ripping or tearing away of a part, often as a result of a sudden strong force.
Axial	Referring to the main axis of the skeleton, including the cranium, spine and torso.

Bending (angulation)	A mode of loading such that the bone bends around its axis and experiences tension on the convex surface and compression on the opposite concave surface.
Bevelling	A slanting edge, usually across a fracture surface.
Buccal	Referring to the surface of a tooth nearest the cheek.
Calculus	Dental tartar.
Caries	Cavity within the teeth, formed as a result of bacterial acid production.
Cariogenic	Conducive to the production of caries.
Compression	A mode of loading where the forces are acting in opposite directions along the longitudinal axis of the bone. Compression results in a decrease in length and an increase in width.
Congenital	Conditions which are present at birth, regardless of their causation.
Contralateral	On the opposite side.
Cortex (cortical)	The outer layer of dense bone.
Costochondral	Referring to the junction between the bone of a rib and its cartilage.
Deciduous	Teeth from the first dentition, normally shed in the course of childhood.
Diaphysis (eal)	The shaft of a long bone prior to the ends fusing.
Disarticulated	Bone or bone elements which are separated from the rest of the skeleton, typically as a result of taphonomic processes.
Distal	Position of the dental arch further from the median line of the jaw OR the portion/end of a long bone which lies farthest away from the midline of the body (usually the lower portion/end).
Dorsal	Refers to the surface of bone opposite to that which is typically forward/to the front or surfaces remaining exposed when muscles are flexed. Most often relates to bone surfaces of the back; however, can also be used to describe the posterior surfaces of the hand bones and the superior surfaces of the foot bones.
Eburnated	Polished or burnished (i.e. shiny, smooth surface).

Elastic deformation	Deformation or strain in bone that is reversible when the stress is released.
Elastic modulus	The ratio of stress to strain in the elastic region of deformation. Because of the anisotropic nature of bone, the moduli in compression and tension differ in bone or the slope of the stress-strain curve. Also known as Young's modulus.
Endocranium	The inner table of the cranium, often referring to the interior surface of the brain case.
Enthesis	A muscle attachment.
Enthesopathy	Disorder affecting attachment of muscle or tendon to bone.
Enthesophyte	A bony outgrowth at the attachment site of a muscle or tendon to bone.
Epicondyle	A landmark eminence above the condyle.
Epiphysis (eal)	Any portion of a bone which is separate to the main diaphysis during growth, but which later fuses following maturity (e.g. the expanded ends of a long bone initially separated from the shaft by cartilage during growth). The term may also be used to describe the proximal and distal ends of the long bones once they are fully fused.
Erosion	Progressive loss of the hard substance of a tooth (or bone cortex) by chemical processes.
Extensor	Any muscle which extends the bones at/across a joint.
Flexor	Any muscle which flexes the bones at/across a joint.
Foramen	A natural opening or passage through the bone.
Fracture	A complete break in bone or cartilage.
Granuloma	A collection of inflammatory cells representing a chronic in flammatory process.
Herniation	The abnormal protusion of a body structure through a defect in muscle or bone.
Haematoma	A localised collection/accumulation of blood in an organ or tissue.
Hypertrophic	Increased amount of bone.
Hypoplasia	Incomplete or under-development of an organ or tissue.

Infraction	An incomplete fracture.
Interproximal	Between the adjacent surface(s) e.g. of the teeth.
Interscapular	The part of the back between the shoulder blades.
Laxity	Stretching of the ligaments.
Limbus vertebra	Protusion of disc material beneath the rim of the vertebral body before this has fused to the rest of the vertebra.
Lingual	Surface of tooth nearest to the tongue.
M. pectoralis major	Muscle which flexes the arm.
M. teres major	Muscle which rotates the arm.
M. supraspinatus	One of the rotator cuff muscles holding the arm in place in its socket (i.e. within the shoulder).
Macromorphoscopic	Shape and form observable by the naked eye.
Macroscopic	Examined with the naked eye.
Mandible (-ular)	The lower jaw (referring to).
Mass grave	A grave containing multiple individuals deposited simultaneously or within a narrow time period (2 – 10+ individuals).
Masticatory	Concerned with process of chewing food.
Maxilla (-ry)	The upper jaw (referring to).
Medial	Towards the midline.
Medial epicondyle	The bony eminence which projects towards the midline at the distal end of the humerus; and forms the attachment for the flexor/pronator complex.
Medullary cavity	The cavity inside a bone, containing the bone marrow in life.
Mesial	Surface of the tooth nearest to the median plane of the dental arch.
Microstructure	The microscopic appearance of the tissues.
MNI	The minimum number of individuals present; used in archaeological recording of human assemblages, typically based on major bone elements.
Neoplasia	Any new or abnormal growth.

NISP	The number of individual specimens; used in archaeological recording of faunal assemblages.
Orthognathic	Characterised by minimal protusion of the mandible, the opposite of prognathism.
Ossification	The conversion of fibrous tissue into a bony structure.
Osteitis	Inflammation of a bone.
Osteological paradox	This represents the universal limitation of human skeletal remains in that they only ever represent those who died within a population (and were buried) and cannot be assumed to represent the whole living population. In addition, when considering prevalences of trauma and disease, only those insults and health crises which produced bony change will be observed upon the skeleton. As this change takes time, individuals who succumb more rapidly or easily (e.g. the frail and very young) or who only suffer soft tissue changes will not demonstrate evidence of their condition or trauma (see Wood et al. (1992) for further detail).
Osteology	The scientific study of bones.
Osteophyte	A bony excrescence.
Overjet	Horizontal overlap (e.g. of the upper jaw).
Pectoral girdle	The bones which connect the upper limb to the axial skeleton, i.e. the clavicle and scapula.
Peri-mortem	Occurring at or around the time of death (referring to events or processes).
Periodontal	Pertaining to the tissues which support the teeth.
Periosteum	A specialised connective tissue covering all the bones of the body.
Periostitis	Inflammation of the periosteum.
Plaque	A soft, thin, film of mucin, food debris and epithelial cells deposited on the teeth.
Plastic deformation	Permanent strain that is unrecoverable when the bone is unstressed. Plastic deformation occurs between the yield point and the failure point.

Postcranial	The part of the skeleton below the cranium.
Post-mortem	Occurring after death (referring to events or processes).
Proximal	The part/portion of a bone closer to any point of reference (usually the midline of the body).
Pseudotrauma	Changes to the bone which mimic aspects of trauma.
Remodelling	The removal and replacement of bone at a particular location by the coupled action of osteoclasts (bone-destructing cells) and osteoblasts (bone-building cells).
Rotator cuff	The group of muscles which hold the arm in place in its socket (i.e. within the shoulder) and which are responsible for over-hand rotation, as typical in throwing movements.
Sacralisation	Fusion of the fifth lumbar vertebra to the first sacral vertebra.
Sacroiliac	The joint between the sacrum and the *Os coxae* (pelvic bone).
Sesamoid bone	A small modular bone embedded in a tendon or joint capsule.
Shear	A force caused by an opposite but parallel sliding motion of the planes of an object.
Spondylolysis	Separation of the body and neural arch of the vertebra.
Sternal	Towards the breast bone (sternum).
Sternoclavicular	The joint between the breast bone and the collar bone (clavicle).
Stiffness (rigidity)	The ability of a material to resist deformation or the load required to cause bone to deform a given amount. It is measured as the slope of the stress-strain curve and influenced by the relative proportion of collagen and hydroxyapatite crystals.
Strain	The dimensional change in loaded bone. The principal strains are normal or shear.
Strength	The ability of bone to withstand permanent deformation (the load at the yield point) or fracture (the load at failure point).
Stress	The load per unit area of a bone, measured in Pascal (Pa). The stress can be normal or shear.
Subchondral	The bone lying beneath the cartilage of an articular surface.
Subluxation	Partial dislocation.

Suppurative	Producing pus.
Suture	Type of fibrous joint where opposing surfaces are closely united.
Syndesmophyte	A bony projection linking two elements which are normally separate; most usually observed at sites of ligamentous attachment, especially vertically oriented growths which form along the margins of vertebral bodies (Buikstra and Ubelaker, 1994: 182).
Tension	A mode of loading in which the forces act in opposite directions along the longitudinal axis of the bone. Tension results in an increase in length and decrease in width.
Torsion (-al)	The process of twisting or rotating around an axis.
Tubercle	A nodule or eminence on a bone e.g. the rotator cuff muscles which hold the arm in place insert on the greater tubercle of the humerus.
Visceral	The internal surface of the ribs.
Yield point	The threshold point where bone begins to deform plastically.

Glossary references

Fiorato et al. (2007) citing adapted definitions from 27th edition of *Dorland's Illustrated Medical Dictionary*, published in 1988 by W. B. Saunders Co.

Buikstra, J. E. and Ubelaker, D. H. (eds.), 1994. *Standards for data collection from human skeletal remains. Proceedings of a seminar at the Field Museum of Natural History, organised by Jonathan Haas*. [Arkansas Archaeological Research Survey Research Series, 44]. Fayetteville, AR: Arkansas Archaeological Survey

APPENDIX A15: Animation of 3D reconstruction of cranial fragments of context 4247

Available on attached disc.