

## Research

### Corresponding author

**Damien Offner, MD, PhD, DDS, DMD**  
 Faculté de Chirurgie Dentaire de  
 Strasbourg  
 Hôpitaux Universitaires de Strasbourg  
 1 place de l'hôpital  
 67000 Strasbourg, France  
 Tel. 0033 6 73 60 57 13  
 E-mail: [damien.offner@hotmail.fr](mailto:damien.offner@hotmail.fr)

Volume 3 : Issue 1

Article Ref. #: 1000DOJ3129

### Article History:

Received: May 5<sup>th</sup>, 2016

Accepted: October 18<sup>th</sup>, 2016

Published: October 18<sup>th</sup>, 2016

### Citation

Offner D, Brisset L, Musset A-M. Cleaning of dental handpieces: A method to test its efficiency, and its evaluation with a washer-disinfector-lubricator-dryer. *Dent Open J.* 2016; 3(1): 10-16. doi: [10.17140/DOJ-3-129](https://doi.org/10.17140/DOJ-3-129)

### Copyright

©2016 Offner D. This is an open access article distributed under the Creative Commons Attribution 4.0 International License (CC BY 4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

# Cleaning of Dental Handpieces: A Method to Test its Efficiency, and its Evaluation With a Washer-Disinfector-Lubricator-Dryer

**Damien Offner, MD, PhD, DDS, DMD<sup>1,2\*</sup>; Lucien Brisset, MD, PhD, DDS, DMD<sup>1</sup>; Anne-Marie Musset, MD, PhD, DDS, DMD<sup>1</sup>**

<sup>1</sup>Faculté de Chirurgie Dentaire de Strasbourg, Hôpitaux Universitaires de Strasbourg, 1 place de l'Hôpital, 67000 Strasbourg, France

<sup>2</sup>Institut National de la Santé et de la Recherche Médicale (INSERM), Unité Mixte de Recherche 1109, Faculté de Médecine, 67085 Strasbourg Cedex, France

## ABSTRACT

**Objectives:** When using dental handpieces (HP), a phenomenon of backflow leads to an external and internal soiling and contamination of HP, especially in their narrow air/water pipes. To prevent any cross-infection, HP need to be sterilized after a thorough cleaning. This work aims to establish and assess a method for testing their cleaning. Indeed, there is a methodological gap concerning its validation because of their complex architecture.

**Materials and Methods:** This method is declined into a protocol using artificial soilings and ninhydrin tests. Its evaluation with a washer-disinfector-lubricator-dryer (WDL) within 2 cleaning cycles with each 6 HP and after control tests, heads to validate its relevance and to demonstrate the effectiveness of the cleaning provided.

**Results:** After each cycle, all HP were externally clean. Our method also showed an internal cleanliness except for 2 HP whose engines in the automaton were defective.

**Conclusion:** This work fits with the improvement of infection control in dental practices. It is the first method developed to control the internal cleaning of HP without having to break them, and it demonstrates the need for HP to be put into an internal rotation during their cleaning. It fills the methodological gaps concerning their cleaning and allows assessing HP cleaning from dedicated WDL. According to standard NF EN ISO15883, the method could be used for initial steps of operational or performances qualifications concerning HP cleaning.

**KEYWORDS:** Dentistry; Infection control; Sterilization.

**ABBREVIATIONS:** WDL: Washer-disinfector-lubricator-dryer; HP: Handpieces; InVS: Institut de Veille Sanitaire.

## INTRODUCTION

Historically, dental rotary instruments were used along with foot-powered dental drills.<sup>1</sup> Nowadays, they are inserted into dental handpieces (HP), and they are put into action with the help of electric motors. These HP are coupled with narrow pipes bringing air and water to cool down the cutting instrument. During a dental surgeon's procedure, the head of the HP is right in the patient's mouth exposing the instruments to the dental organ and soft tissues and in direct contact with saliva or other biological fluids (blood, pus) in a real septic environment. HP is heat-sensitive, and they are classified as semi-critical reusable medical devices according to the Spaulding classification.<sup>2,4</sup> Therefore, they should follow a complete sterilization cycle before their reutilization.

Moreover, when the HP stops working while performing dental procedure, a physical

phenomenon of backflow occurs.<sup>5-11</sup> Since the head of the HP is running in a septic environment, a retro-contamination and an internal soiling (Figure 1) of the HP occurs, consequently causing external contamination and soiling. This contamination takes place at different levels of the head and body of the HP,<sup>10-17</sup> and the narrow pipes dedicated to bring air and water to the dynamic instrument.<sup>18,19</sup>



Figure 1: Dismantled HP with inner and outer soiling (Courtesy of Dr. JP Mangion).

Indeed, the head of the HP is not isolated from its body, neither in a watertight nor in an airtight way. This clearly appears by applying compressed air at one end of the head and observing an air outlet to the other end.

This internal contamination can spread to the engine that puts the HP in action, and the contamination of the air/water pipes can spread to the entire unit waterline.<sup>6,8</sup> The latter can then constitute a secondary reservoir of microorganisms which are aggregated in biofilms. These biofilms could potentially grow from microorganisms that come from the mouth of patients and from the general water supply network. Far from being trivial, the contamination of a unit waterline can lead to serious infections, and even death of patients.<sup>21</sup> Therefore, the risk of infection is real, and the management of this risk should be seriously integrated in the context of the safety of the procedures.<sup>22</sup>

If the contaminated HP does not follow an adequate treatment, it can then become a source of cross-infection endangering the health of the following patients and the health of the healthcare team by exposing them to an increasing risk of infections.<sup>5,6,14,19,20</sup> Contamination of HP can be of various kinds; many pathogens were found in the HP, such as hepatitis B virus,<sup>13</sup> or *Pseudomonas spp* and *Staphylococcus aureus*.<sup>19</sup> A mathematical modeling conducted by the Institut de Veille Sanitaire (InVS) in 2009 shows that each year in France, the neglected treatment of HP would be responsible for 200 contaminations caused by the virus of hepatitis B, 2 contaminations by the virus of hepatitis C, and one by HIV.<sup>11</sup>

To expose patients to this infectious risk while there are ways to minimize it, including a correct treatment of HP, is

ethically unacceptable.<sup>2,5,23</sup> In order to be in good standing with the regulations concerning the treatment of semi-critical medical devices in dentistry, it is necessary, essential and mandatory to sterilize HP between each patient.<sup>2-5,8-10,14,15,17,18,24-27</sup> To ensure a complete and efficient sterilization of HP and any other instrument, and to ensure that the steam can reach the whole surface that has to be sterilized, the instruments must previously be cleaned.<sup>3,4,14,20,21,28-30</sup> Many studies also emphasized this point that it is essential that HP benefit from an optimal cleaning to ensure the effectiveness of their sterilization.<sup>10,12,27,32-34</sup> On one side, the external cleaning of HP does not raise problems. On the other side, great difficulties remain to realize internal cleaning effectively<sup>22,31,35</sup> mainly because of the complex internal architecture of HP, and the very reduced dimensions of the air/water pipes.<sup>22,28,34,36</sup>

Many manufacturers have tried to develop an automaton to perform a thorough cleaning of HP, both external and internal. They were faced with the difficulty to develop such an automaton,<sup>31,33,37,38</sup> because residues still remain on the surfaces which should appear clean, even if the cleaning machine is more effective than the manual cleaning.<sup>31</sup> Moreover, it is difficult to assess the good internal cleaning of HP because they are fragile and mostly designed not to be dismantled. Literature also raises the question of a proven method to control the good internal cleaning of HP which is a problem concerning HP that are not meant to be dismantled.<sup>15,28,35</sup> Indeed, the standards for the general requirements of washer-disinfectors performances<sup>39</sup> advocates a visual validation of the good cleaning of instruments required to ensure a complete and effective sterilization cycle. If this validation does not raise problems for full instruments, it is not the case for the hollow instruments, neither is it for the ones that should not be dismantled.

## OBJECTIVE

The aim of this original study is to develop a validation method of the external and internal cleaning of HP without being destructive. The secondary objective is to assess the method by applying it with a washer-disinfector-lubricator-dryer (WLDL) dedicated to HP.

## MATERIALS AND METHODS

Tests have been thought for the operator to be able to visualize the inside of the HP. Since the task is accurate and meticulous, the tests cannot be considered as a routine, and they participate in the originality of our work. The tests took place within 2 cycles according to the following protocol, after having performed control experiments.

Soil Test<sup>®</sup> (Browne/STERIS, Le Haillan, France) was used, and tests with Ninhydrin (CleanTrace<sup>®</sup>, 3M, Cergy, France) were also performed in order to assess the presence or absence of protein residues, and therefore validate the surfaces

cleanliness. The WDL used during these tests was the Bioda<sup>®</sup> (vr2m, Semoy, France).

### The Protocol

1. Dismantle the HP (Figure 2).
2. Stain the outside (body of the HP) and inside (air/water pipes, gears) using Soil Test<sup>®</sup>. Also, stain the load racks (block support for the HP, sides of the tank). Soil Test<sup>®</sup> was chosen because of the good adaptability of the form in which it is presented to the protocol that is described, and its adequacy with biological fouling.<sup>40</sup>  
The head of the HP is stained using a Soil Test<sup>®</sup> syringe. The air/water pipes are stained using a Soil Test<sup>®</sup> syringe whose mouthpiece is suitable for their diameter. The pressure on the plunger of the syringe will be made until the Soil Test<sup>®</sup> comes out by the other side of the pipe.
3. Reassemble the HP.
4. Connect the HP in the automaton (Figure 3), and run a cycle with inactivation of the disinfection phase (as specified in the standard NF EN ISO 15883-1 for washing tests).<sup>39</sup>
5. Visually observe the presence/absence of soiling residues on the outside of the HP. Perform a test with Ninhydrin (CleanTrace<sup>®</sup>) in case of absence.
6. Dismantle the HP.
7. Visually observe the presence/absence of residues of soiling. Push a 0.7 mm diameter nylon thread through the air/water pipes over a clean plate. The thread is adjusted to the diameter of the pipe and will displace any remaining residual soiling that will be observable upon its release. Observe the pres-

ence of soiling on the end and/or on the body of the thread under the microscope. Observe the presence of deposits on the plate. Perform a test with Ninhydrin (CleanTrace<sup>®</sup>) on the thread in case of absence.

8. Reassemble the HP/start again at point 2. for a new cycle.

### Control Experiments

1. Control tests were performed on an artificially soiled HP according to the steps described in this protocol, but without the cleaning step (Step 4).
2. Steps 5 to 8 of the protocol were followed on a HP which was naturally soiled during a normal use in dental surgery practice and treated routinely with a manual cleaning.

### First Cycle

The first tests cycle was carried out on 6 universal-fitting HP (valid for HP from brands such as WH<sup>®</sup>, BienAir<sup>®</sup>, MicroMega<sup>®</sup>, Mont Blanc<sup>®</sup>, etc.). The cleaning cycle has been set to 15 minutes, using Deconex<sup>®</sup> (Borer Chemie AG, Zuchwil, Switzerland) as detergent at 8 ml/L of water. During the start-up of the cycle, 2 HP were turning on themselves, showing an absence of rotation of the internal bearings. The engine examination of the support brackets confirmed that they were defective.

### Second Cycle

The second cycle was carried out on the same 6 universal-fitting HP, previously cleaned before being soiled again using Soil Test<sup>®</sup>. The cleaning cycle has been set to 4 minutes, using the

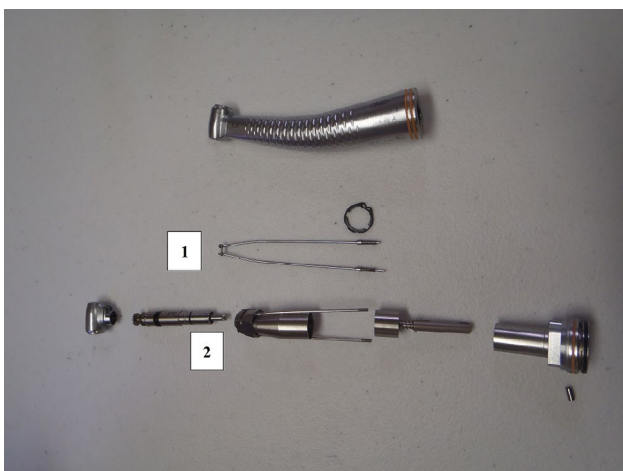


Figure 2: Dismantle of the HP.

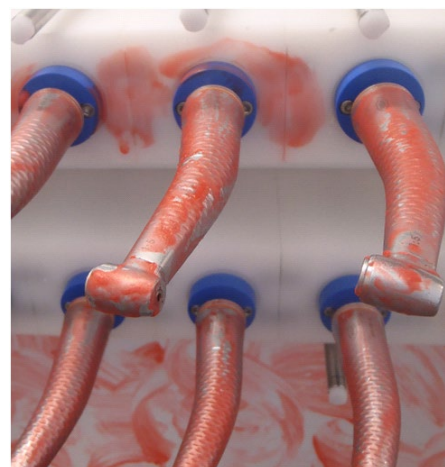


Figure 3: Connection of the soiled HP in the automaton. Soiled load racks and tank sides.

VR-DYME® (vr2m, Semoy, France) as detergent. The engines were changed and during the cycle, the entire HP has shown in internal rotation.

**RESULTS**

**Control Tests**

1. The control tests confirm the presence of Soil Test® in the air/water pipes and validate the relevance of pushing the nylon thread through these, because the thread highlights the internal staining of these pipes (Figure 4).
2. The control test on the HP stained during a normal use and treated manually in routine shows residues inside the head of the HP (Figure1) and the air/water pipes. Ninhydrin tests have been performed by swabbing the thread in both situations, and the results were positive (turning to purple) (Table 1).

**First cycle**

At the end of the washing cycle (15 minutes), HP have been disconnected from the WDL and handled with gloves. Visual examination showed a lack of residual soiling on the body of the

HP as well as on the load racks.

After dismantling the HP, the areas likely to be soiled in a usual dental surgeon’s practice appeared to be clean on the 4 HP for which the motor worked properly. The nylon thread in the pipes showed neither deposit on the thread itself nor on the plate over which it was conducted (Figure 5). Ninhydrin tests were performed on these soilless surfaces, and the results were negative. Concerning the 2 HP which had not been put into an internal rotation, a residual soiling was apparent on the half of the surface of one gear, the other half appeared clean (Table 1). This is shown on Figure 6 through the blue marker and demonstrates the importance of the internal rotation of the HP during the cleaning cycle.

**Second cycle**

At the end of the washing cycle (4 minutes), the HP have been disconnected from the WDL and handled with gloves. Visual examination showed a lack of residual soiling on the body of the HP as well as on the load racks.

After having dismantled the HP, the areas likely to be soiled in a usual dental surgeon’s practice appeared to be clean.

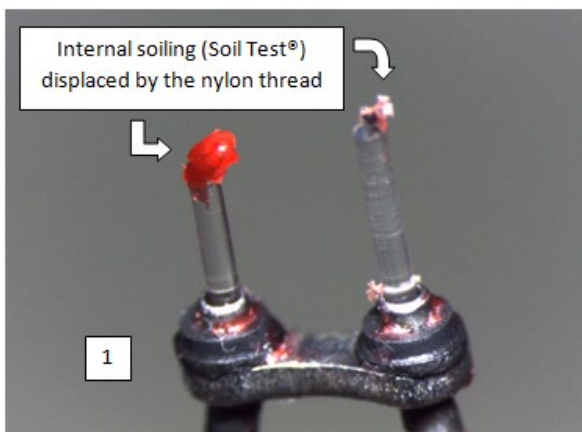


Figure 4: Highlighted interest of pushing a nylon thread through the air/water pipes.

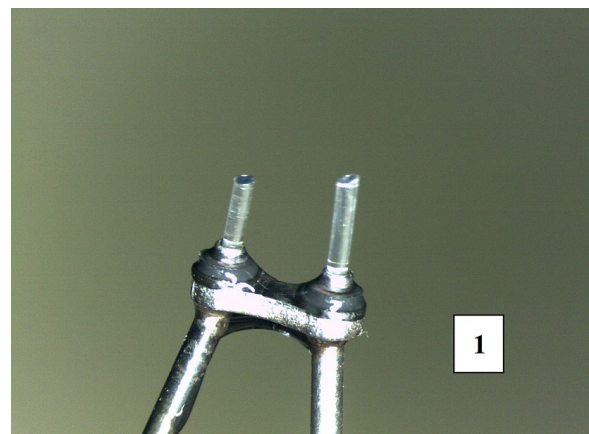


Figure 5: Highlighted cleanliness of the air/water pipes of the HP.

Experiment	Type of soiling	Number of HP	Protocol steps	Cleaning modalities	Results
Control test 1	Soil Test®	1	All but 4	No cleaning	External and internal soiling
Control test 2	Soiling during normal use in dental practice	1	5 to 8	Manual cleaning	External cleanliness Internal soiling
1 <sup>st</sup> cycle	Soil Test®	6	1 to 8	WDL with Deconex®	External cleanliness Internal cleanliness except for 2 HP whose engine on the support brackets were defective
2 <sup>nd</sup> cycle	Soil Test®	6	1 to 8	WDL with VR-DYME®	External and internal cleanliness

Table 1: Modalities and results of the tests.



**Figure 6:** Highlighted soiling on the half of the same gear, due to the non-internal rotation of the HP.

Ninhydrin tests were performed on these soiless surfaces and were negative.

The nylon thread in the pipes showed no deposit on the thread itself, or on the plate over which it was conducted. Ninhydrin tests were performed on the nylon threads, and the results were negative (Table 1).

## DISCUSSION

This protocol is the first protocol proposed to control the internal cleaning of the HP without having to destroy them. Such a method of evaluation can easily be used in the initial steps of an operational qualification or a qualification of the performance of a WDL. Indeed, the standard for the general requirements of washer-disinfectors performances<sup>39</sup> demands a primary validation of the cleaning of the HP using an artificial soiling before their use in an actual practice.

In two cycles, the tests show the effectiveness of the cleaning. Indeed, the HP and the load racks appear clean after the two cycles (15 minutes, and even after a shorter cycle of 4 minutes). Disassembly also shows a cleaning efficiency in the visible areas beneath the body of the HP and into the air/water pipes as well. Finally, the results of these tests are confirmed by the absence of reaction with Ninhydrin.

The tests also show that it is essential that the HP kept in internal rotation (as it is when they are used by the dental surgeon as he is working in the patient's mouth) during the cleaning process. Indeed, a lack of internal rotation, as it was the case for 2 HP in the first cycle produces an incomplete cleaning because fluids cannot reach all the surfaces.

This validation method is consistent with the initial applications of standard NF EN ISO 15883 concerning the cleaning of the instruments. However, some limits should be mentioned; since the final validation of the cleaning is based on a visual assessment (as required in the standard NF EN ISO 15883), it is impossible to scientifically ensure the good cleaning inside the parts of bearing without damaging the equipment, because they are not removable and are not accessible to swabs or ny-

lon threads. The protocol appears to be meticulous to achieve, and the manipulations are very delicate because they were made on HP that are not designed to be disassembled and once items are removed, they are easily breakable. It may very well find its place into the initial qualifications of an automaton dedicated to the treatment of the HP, but it seems hardly applicable to periodic requalification of these automata in a routinely dental practice.

Other tests may be performed in the future in order to strengthen the relevance of this method in order to optimize the automaton washing time and to assess the performances of any other WDL.

## CONCLUSION

HP's are reusable semi-critical medical devices that generate soilings and contaminations through the backflow phenomenon inter alia located on the outer surface, inner surface and in the narrow air and water pipes. This initial contamination can become the source of cross-contaminations. Additionally, the good treatment of HP is a regulatory obligation that must follow a sterilization process between each patient, preceded by an effective cleaning.

The validation method of the cleaning of the HP presented in this article clearly fits with an approach of improving the safety of practices, and the management of the risk of infection in dental care procedures, both for patients and for the healthcare team. It fills the methodological gaps concerning the cleaning of the HP as required in the standard NF EN ISO 15883. Although its implementation is meticulous and accurate, it allows at lower cost to assess the HP cleaning.

## ACKNOWLEDGMENTS

We thank Guillermo Tejada and Maxime Schall for their help in proofreading.

## CONFLICTS OF INTEREST

All authors report no conflicts of interest relevant to this article.

**FINANCIAL SUPPORT:** None reported.

## REFERENCES

- Société Française de l'Histoire de l'Art Dentaire (SFHAD). *Histoire de l'aménagement opératoire du cabinet dentaire*, on-line information. Web site. [www.biusante.parisdescartes.fr/sfhad](http://www.biusante.parisdescartes.fr/sfhad). Accessed May 4, 2015.
- Brisset L, Lécolier MD. *Hygiène et asepsie au cabinet dentaire* [In French]. Issy-les-Moulineaux, France: Masson; 1997: 198.
- Ministère de la Santé, DGS. *Guide de prévention des infections liées aux soins en chirurgie dentaire et en stomatologie* [In French]. 2006. Web site. [http://social-sante.gouv.fr/IMG/pdf/Guide\\_de\\_prevention\\_des\\_infections\\_liees\\_aux\\_soins\\_en\\_chirurgie\\_dentaire\\_et\\_en\\_stomatologie.pdf](http://social-sante.gouv.fr/IMG/pdf/Guide_de_prevention_des_infections_liees_aux_soins_en_chirurgie_dentaire_et_en_stomatologie.pdf). Accessed May 4, 2015.
- Association Dentaire Française (ADF). *Grille technique d'évaluation pour la prévention des infections associées aux soins* [In French]. 2013. Web site. [http://www.fncs.org/sites/default/files/pdf/GRILLE\\_DEVALUAT\\_DES\\_CAB\\_DENTAIRE\\_oct\\_2011.pdf](http://www.fncs.org/sites/default/files/pdf/GRILLE_DEVALUAT_DES_CAB_DENTAIRE_oct_2011.pdf). Accessed May 4, 2015.
- Pankhurst CL, Johnson NW, Woods RG. Microbial contamination of dental unit waterlines: The scientific argument. *Int Dent J*. 1998; 48: 359-368. doi: [10.1111/j.1875-595X.1998.tb00697.x](https://doi.org/10.1111/j.1875-595X.1998.tb00697.x)
- Sacchetti R, Baldissarri A, De Luca G, Lucca P, Stampi S, Zanetti F. Microbial contamination in dental unit waterlines: comparison between Er: Yag laser and turbine lines. *Ann Agric Environ Med*. 2006; 13: 275-279.
- Petti S, Moroni C, Messano GA, Polimeni A. Detection of oral streptococci in dental unit water lines after therapy with air turbine handpiece: Biological fluid retraction more frequent than expected. *Future Microbiol*. 2013; 8(3): 413-421. doi: [10.2217/fmb.12.151](https://doi.org/10.2217/fmb.12.151)
- Chin JR, Miller CH, Palenik CJ. Internal contamination of air-driven low-speed handpieces and attached prophylaxis angles. *J Am Dent Assoc*. 2006; 137(9): 1275-1280. doi: [10.14219/jada.archive.2006.0386](https://doi.org/10.14219/jada.archive.2006.0386)
- Chin JR, Westerman AE, Palenik CJ, Eckert SG. Contamination of handpieces during pulpotomy therapy on primary teeth. *Pediatr Dent*. 2009; 31(1): 71-75. Web site. <http://www.ingentaconnect.com/content/aapd/pd/2009/00000031/00000001/art00011>. Accessed May 4, 2016.
- Checchi L, Montebugnoli L, Samaritani S. Contamination of the turbine air chamber: A risk of cross-infection. *J Clin Periodontol*. 1998; 25(8): 607-611. doi: [10.1111/j.1600-051X.1998.tb02495.x](https://doi.org/10.1111/j.1600-051X.1998.tb02495.x)
- Institut de Veille Sanitaire (INVS). Analyse du risque infectieux lié à la non-stérilisation entre chaque patient des porte-instruments rotatifs en chirurgie dentaire [In French]. 2009. Web site. [http://invs.santepubliquefrance.fr/publications/2009/risques\\_chirurgie\\_dentaire/index.html](http://invs.santepubliquefrance.fr/publications/2009/risques_chirurgie_dentaire/index.html). Accessed May 4, 2016.
- Hu T, Meng X, Zuo Y, Zhou X. A study on bacterial contamination of dental handpieces. *Hua Xi Kou Qiang Yi Xue Za Zhi*. 2001; 19(2): 93-4, 98.
- Deng XH, Sun Z, Qiao H, Deng HY, Xiao X, Su J. The possibility of hepatitis B virus transmission through dental handpieces. *Zhonghua Yu Fang Yi Xue Za Zhi*. 2005; 39(3): 199-202.
- Larsen T, Andersen HK, Fiehn NE. Evaluation of a new device for sterilizing dental high-speed handpieces. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*. 1997; 84(5): 513-516. doi: [10.1016/S1079-2104\(97\)90268-7](https://doi.org/10.1016/S1079-2104(97)90268-7)
- Ojajärvi J. Prevention of microbial contamination of the dental unit caused by suction into the turbine drive air lines. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*. 1996; 81: 50-52. doi: [10.1016/S1079-2104\(96\)80147-8](https://doi.org/10.1016/S1079-2104(96)80147-8)
- Smith A, Smith G, Lappin DF, Baxter HC, Jones A, Baxter RL. Dental handpiece contamination: A proteomics and surface analysis approach. *Biofouling*. 2014; 30(1): 29-39. doi: [10.1080/08927014.2013.839782](https://doi.org/10.1080/08927014.2013.839782)
- Herd S, Chin J, Palenik CJ, Ofner S. The in-vivo contamination of air-driven low-speed handpieces with prophylaxis angles. *J Am Dent Assoc*. 2007; 138(10): 1360-1365. doi: [10.14219/jada.archive.2007.0053](https://doi.org/10.14219/jada.archive.2007.0053)
- Dreyer AG, Hauman CH. Bacterial contamination of dental handpieces. *SADJ*. 2001; 56(11): 510-512. Web site. <http://europepmc.org/abstract/med/11885426>. Accessed May 4, 2016.
- Smith G, Smith A. Microbial contamination of used dental handpieces. *Am J Infect Control*. 2014; 42(9): 1019-1021. doi: [10.1016/j.ajic.2014.06.008](https://doi.org/10.1016/j.ajic.2014.06.008)
- Lewis DL, Boe RK. Cross infection risks associated with current procedures for using high-speed dental handpieces. *J Clin Microbiol*. 1992; 30(2): 401-406.
- Ricci ML, Fontana S, Pinci F, et al. Pneumonia associated with a dental unit waterline. *Lancet*. 2012; 379(9816): 684. doi: [10.1016/S0140-6736\(12\)60074-9](https://doi.org/10.1016/S0140-6736(12)60074-9)
- Weightman NC, Lines LD. Problems with the decontamination of dental handpieces and other intra-oral dental equipment in hospitals. *J Hosp Infect*. 2004; 56(1): 1-5. doi: [10.1016/j.jhin.2003.09.006](https://doi.org/10.1016/j.jhin.2003.09.006)
- Offner D. Motiver et remotiver l'équipe soignante d'un cab-

- inet dentaire à l'application des mesures d'hygiène par une expérience de pensée éthique [In French]. *Ethique et Santé*. 2013; 10: 18-21. doi: [10.1016/j.etiqe.2012.11.001](https://doi.org/10.1016/j.etiqe.2012.11.001)
24. Hauman CH. Crossinfection risks associated with high-speed dental handpieces. *J Dent Assoc S Afr*. 1993; 48(7): 389-391.
25. Samaranayake L. Handpiece and water line decontamination and HIV transmission: A critique. *Dent Update*. 1993; 20(2): 53-4, 56.
26. Deng XH, Sun Z, Su J. Current status of disinfection and sterilization for dental handpieces in the hospitals. *Zhonghua Yu Fang Yi Xue Za Zhi*. 2004; 38(6): 365-368.
27. Young JM. Keys to successful handpiece maintenance. *Tex Dent J*. 1997; 114(12): 15-19.
28. Perrin D. *Les Instruments Dynamiques. Clinic*. 1999; 20(7).
29. Thiveaud D. Du nettoyage à la stérilisation. Le lavage: l'étape essentielle [In French]. *Hygienes*. 2: 27-34.
30. Arbeitskreis Instrumentenaufbereitung. *Traitement correct des instruments de chirurgie* [In French]. 8<sup>th</sup> ed. 2004. Web site. [www.a-k-i.org](http://www.a-k-i.org). Accessed January 2015.
31. Zhou X, Huang H, He X, Chen H, Zhou X. Effect of manual cleaning and machine cleaning for dental handpieces. *Hua Xi Kou Qiang Yi Xue Za Zhi*. 2013; 31(4): 369-371.
32. Chassot E. *Le nettoyage en priorité, 3<sup>ème</sup> symposium international de Bâle* [In French]. 2006. Web site. [www.sssh.ch](http://www.sssh.ch). Accessed January 2015.
33. Smith GW, Smith AJ, Creanor S, Hurrell D, Bagg J, Lappin DF. Survey of the decontamination and maintenance of dental handpieces in general dental practice. *Br Dent J*. 2009; 207(4): 160-161. doi: [10.1038/sj.bdj.2009.761](https://doi.org/10.1038/sj.bdj.2009.761)
34. Musso P. Le lavage des dispositifs médicaux en stérilisation dans les établissements de santé: évolution, aspects techniques et réglementaires [In French]. *IRBM News*. 2007; 28(4): 24-31.
35. Kudhail R. Can oil lubricated dental handpiece be sterilized?: part 2. Literature review. *Dent Update*. 2013; 40(8) : 630-632.
36. Arbeitskreis Instrumentenaufbereitung. *Traitement correct des instruments dans les cabinets dentaires* [In French]. 3<sup>rd</sup> ed. 2005. Web site. [www.a-k-i.org](http://www.a-k-i.org). Accessed January 2015.
37. Walker J, Kingston R, Chell K. Evaluation of washer disinfectant for use in dental practices. The preliminary program for IADR General Session – poster. 2010.
38. Simonetti D'Arca AS, Petti S, Tomassini E, Polimeni A. A new device for the disinfection of handpieces and turbines. *Minerva Stomatol*. 1995; 44(7-8): 369-375.
39. *Norme NF EN ISO 15883 parties 1 et 2 relatives aux exigences générales des performances des laveurs-désinfecteurs* [In French]. 2009.
40. Association Française de Stérilisation (AFS). *Qualification et requalification des laveurs-désinfecteurs* [In French]. 2009. Web site. [www.afs.asso.fr](http://www.afs.asso.fr). Accessed January 2015.