Article

Compliance of the Dryness of Dental Handpieces for Their Sterilization under Various Treatment Conditions

Axel Fruhauf 1,2, Gabriel Fernandez de Grado 1,2,3 ○, Julie Scholler 2 and Damien Offner 1,2,3,* ○

1 Faculté de Chirurgie Dentaire Robert Frank, Université de Strasbourg, 8 rue Ste Elisabeth, F-67000 Strasbourg, France
2 Hôpitaux Universitaires de Strasbourg, 1 Place de l’Hôpital, F-67000 Strasbourg, France
3 French National Institute of Health and Medical Research (INSERM), UMR 1260, Regenerative Nanomedicine (RNM), FMTS, F-67000 Strasbourg, France
* Correspondence: doffner@unistra.fr

Abstract: Objectives: In the protocol for cleaning and sterilizing dental handpieces (DHs), water retention within the instrument poses a challenge and may compromise the sterilization process. This study aimed to assess the reliability and reproducibility of the sterilization protocol regarding the dryness of DHs. It evaluated the presence of residual water in these instruments after various conditions of treatment through multiple dryness tests. Methods: This comparative study examined the dryness of seven different DHs following five washing–disinfection and/or sterilization protocols. Dabbing tests, shaking by hand, or compressed air tests through DHs and over absorbent paper were employed to ascertain the thorough dryness of DHs after treatment. As soon as the first sign of water appeared on the absorbent paper, the DH was deemed to be not dry. Results: Upon completion of the washing–disinfection protocol without sterilization, five out of seven DHs were deemed dry using the dabbing test, yet none were fully dry when subjected to shaking or compressed air. However, in the four protocols incorporating final sterilization, all DHs were dry according to the three drying tests. Conclusion: This study underscores the essential role of the sterilization step in eliminating residual water from DHs, thereby ensuring optimal conditions for effective sterilization in terms of dryness. Furthermore, the study recommends against relying solely on the dabbing drying test, emphasizing the importance of shaking or using compressed air to confirm instrument dryness.

Keywords: dentistry; sterilization; infection control; hygiene; handpieces

1. Introduction

The dental office presents an environment rich in various microorganisms, originating from external surroundings, patients themselves, or directly from the dental unit’s water system [1,2]. Daily usage of dental instruments contributes significantly to microorganism dissemination, particularly through the aerosolization of potentially microorganism-laden particles in the patient’s vicinity [3]. Working within a patient’s oral cavity, a septic environment, dental handpieces (DHs) serve as prime entry points for contamination. This contamination can occur externally through fluids projected onto the DH and its surrounding treatment area up to 1.5 m [4], as well as internally through a retrocontamination phenomenon within DHs. This reflux introduces microorganisms directly into the instrument, posing a risk of biofilm proliferation within the DH or even throughout the dental unit’s tubing [5,6]. Such contaminations and biofilms can lead to cross-infections and transmissions, including viruses such as hepatitis B virus (HBV) or HIV [6]. Hence, it is imperative for dentists to adhere strictly to a protocol for managing DHs, from washing to sterilization.

Regularly, sterilization defects in dental practice are brought to public attention [7]. It may concern DHs or other semi-critical reusable medical devices. In October 2023, approximately 5000 patients from hospitals in the “Hautes-Pyrenees” region in France
were advised to undergo screening for HBV, hepatitis C virus (HCV), and HIV due to a sterilization equipment failure related to dental care, with some cases dating back over a decade [8]. While the likelihood of transmission is low, the risk is real for both patients and healthcare teams [7]. DHs, classified as semi-critical reusable medical devices according to the Spaulding classification, possess complex internal architectures and are not designed for disassembly due to fragility, making their cleaning even more challenging. The canals allowing the passage of water and air within these instruments are conducive to the development of microbial biofilms; this occurs because canals are narrow, humid spaces traversed by a laminar flow that can be contaminated by the retrocontamination phenomenon from the patient’s mouth or by contamination from the water circulating in the dental unit [9].

After dental treatment, used DHs should not be placed in a soaking tray to avoid corrosion or deactivation of the disinfectant product due to bubbles inside the canals [10]. Instead, they should be stored in a moist cloth inside a sealed box until further processing or placed directly in a washer–disinfector–lubricator–dryer for a determined time specified by the machine [11]. The use of washer–disinfectors has been proven to have a cleaning action on DHs, even on internal components of multiple DHPs at the same time [12]. Washing–disinfection and lubrication steps can be separate or performed in the same device if the automation is capable of handling both. Subsequently, DHs are packaged for final sterilization. Steam sterilization using an autoclave involves a process with multiple stages, including an initial vacuum phase followed by a temperature increase to reach a plateau of $134^\circ C$ for 18 min [13,14]. To ensure the effectiveness of sterilization, steam must reach the cavities and external/internal surfaces of DHs. A class-B steam sterilizer conforming to EN 13060 is required for this sterilization process. The oil resulting from DH lubrication may pose a challenge in allowing steam to contact surfaces, but the heat transfer from steam to oil is sufficient to eliminate microorganisms not directly accessible to the steam [15]. Indeed, one might have thought that the oil interface created between the surface of the medical device and the steam could have led to a reduction in the energy required to sterilize the surfaces. The presence of residual water in DHs could also impede optimal sterilization.

It is recognized that steam must spread over dry instruments during sterilization to be effective. Despite adhering to this protocol, a recent study demonstrated the persistence of water in DHs after the cleaning phase in the washer–disinfector [16]. Therefore, it seemed crucial to conduct a study on the quality of DH dryness after a sterilization cycle to ensure that sterilization occurs under optimal conditions. Thus, the goal of our study was to assess the reliability and reproducibility of the sterilization protocol regarding the dryness of DHs by evaluating the presence of residual water in these instruments after various conditions of treatment through multiple dryness tests. A secondary objective was to discriminate the relevance of these various dryness tests. As such, our study hypothesis was that, despite the residual water present after exiting the washer–disinfector, the dryness required for sterilization compliance is achieved during the sterilization cycle.

2. Materials and Methods

2.1. Protocols

For this study, we selected seven distinct DHs from various brands (W&H®, NSK®, and Kavo®) and subjected them to five different maintenance protocols. Each protocol involved using the same seven DHs after routine dental care, initially processed in the same washer–disinfector utilized in the 2021 study: Teon+ (W&H®, Eckbolsheim, France [16]. Subsequently, following each protocol, the seven DHs underwent dryness tests using dabbing over absorbent paper, shaking by hand over the same absorbent paper, and medical compressed air over the same absorbent paper. The dryness state was assessed as either dry or not dry.

The protocols were as follows (Table 1).
Table 1. Study outline.

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<td>Washer–Disinfector</td>
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<tr>
<td>Test</td>
<td>Sterilization</td>
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Protocol 1: DHs were treated in a washer–disinfector (Teon+, W&H®, Eckbolsheim, France) with bases for DHs (Figure 1), without subsequent lubrication or sterilization.

Protocol 2: DHs were treated in a washer–disinfector (Teon+) with bases for DHs, followed by a cycle of sterilization in an autoclave.

Protocol 3: DHs were treated in a washer–disinfector (Teon+) with bases for DHs, followed by compressed air passing through each DH for 3 s, followed by a sterilization cycle in an autoclave.

Protocol 4: DHs were treated in a washer–disinfector (Teon+) with bases for DHs, with lubrication of each instrument using Assistina Twin (W&H®, Eckbolsheim, France), followed by a sterilization cycle in an autoclave.

Protocol 5: DHs were treated in a washer–disinfector (Teon+) with bases for DHs, followed by compressed air passing through each DH for 3 s, followed by lubrication using Assistina Twin, followed by a sterilization cycle in an autoclave.

Figure 1. Washer–Disinfector Teon+ (W&H, Eckbolsheim, France) with bases for DHs.
2.2. Statistical Analysis

A Chi-square statistical test was performed to ascertain whether there existed a significant difference in the results among the various tests and protocols. Statistical analysis was performed using the BiostaTGV online platform (https://marne.u707.jussieu.fr/biostatgv/ (accessed on 14 February 2024)) developed by INSERM (“Institut National de la Santé et de la Recherche Médicale”, Paris, France). A p-value lower than 0.05 was considered statistically significant.

3. Results

Upon completion of protocol 1, five out of the seven DHs were considered dry according to the dabbing test, and two were not dry (Figure 2). However, none were entirely dry when subjected to shaking or compressed air, indicating residual water within the internal channels. Notably, the dabbing test failed to detect this water in five DHs.

![Image of dryness tests](image-url)

**Figure 2.** Dryness tests: (A) dabbing test (here, “not dry” result); (B) shaking test (here, “not dry” result); and (C) compressed air test (here, “not dry” result).

In contrast, following protocol 2 and subsequent completion of all three drying tests, we observed that all DHs were completely dry, regardless of the test performed. This trend persisted in protocols 3–5 (Table 2).

**Table 2.** Results of the dryness tests following various DHs treatment protocols (number of dry DHs out of a total of 7).

<table>
<thead>
<tr>
<th>Protocol</th>
<th>Dabbing</th>
<th>Shaking</th>
<th>Compressed Air</th>
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<tbody>
<tr>
<td>Protocol 1</td>
<td>5/7</td>
<td>0/7</td>
<td>0/7</td>
</tr>
<tr>
<td>Protocol 2</td>
<td>7/7</td>
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<td>Protocol 3</td>
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<tr>
<td>Protocol 5</td>
<td>7/7</td>
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NS: Non-significant (p > 0.5); *: p < 0.01; and **: p < 0.001.

Statistical analysis revealed a significant difference in results between protocol 1 and the other protocols for shaking and compressed air tests (p-value < 0.001). However, no
significant difference was found with the dabbing test ($p$-value > 0.5). Moreover, when comparing only the test results, a significant difference was noted between the dabbing test and shaking or compressed air ($p$-value < 0.01).

While the four protocols differ, they all include the final sterilization step, unlike protocol 1. This suggests that the final sterilization stage aids in removing residual water post-cleaning and disinfection.

Additionally, in the last two series involving lubrication, a minor trace of oil was detected in one out of the fourteen sterilization pouches (Figure 3).

![Figure 3. (A) Oil stain on the sterilization pouch, visible in the red circle. (B) Water stain on the sterilization pouch, visible in the blue circle.](image)

### 4. Discussion

Regarding the dabbing test, during protocol 1, it was noted that it failed to detect residual water in five out of the seven DHs utilized in the study. This observation could have skewed the results had the dabbing test been the sole dryness assessment method. However, by shaking the DHs or applying compressed air internally, we were able to extract the water trapped inside. Additionally, upon comparing the images from the dryness tests, it became evident that the dabbing method yielded considerably less water compared to the other two tests. Therefore, for dryness assessments of DHs, it is advisable to exclude the dabbing test and instead utilize the compressed air test, which provides a more accurate indication of water presence.

Another hypothesis that emerges is that residual water inside the DHs after the cleaning phase may be expelled during the vacuum phase of the autoclave. This is supported by the observation that only protocol 1, lacking a sterilization cycle, exhibited humidity within several DHs. Through this water expulsion during the vacuum phase, the DHs become dry and are primed for effective sterilization. Our study hypothesis is, therefore, verified. Consequently, not only is it recommended to sterilize the DHs for practice safety, but the sterilization cycle itself becomes compliant through the expulsion of moisture it facilitates.
Additional drying of the DHs prior to sterilization (shaking and compressed air), thus, appears unnecessary for their dryness before sterilization.

However, questions persist regarding lubrication and its place in the decontamination protocol. If lubrication occurs before sterilization with residual water present, its efficacy may be compromised due to the immiscibility of water and oil. One potential solution could be post-sterilization lubrication with sterile oil [17] or advocating for manufacturers to enhance their drying procedures. Lubricating DHs does not impede their sterilization compliance [15]; rather, it is essential for extending their lifespan and ensuring optimal functionality. It is imperative to ensure that lubrication is performed in a compliant manner.

Regarding the detection of oil traces on the packaging, it may be challenging to distinguish them from water stains (Figure 3). The threshold size beyond which the cycle should be repeated remains unclear. Indeed, packaging that comes out of the sterilizer with a stain on its surface can be deemed non-compliant and may require another sterilization cycle, leading to wasted time and money. There are no clear recommendations regarding this decision: Does an oil stain on the packaging have the same impact as a water stain? Does the size of the stain affect compliance? However, the efficacy of lubrication in humid conditions, when conducted before sterilization, remains a question for manufacturers to address. Presently, various devices on the market offer washing, disinfecting, and lubricating capabilities simultaneously, streamlining the process. While the time-saving aspect of these automated systems is noteworthy, ensuring the accurate execution of all three steps takes precedence over operational efficiency.

In response to a secondary objective of our study, we recommend conducting a drying test of DHs using compressed air or shaking rather than dabbing, as these methods have been proven to be more reliable.

Nevertheless, our study has limitations. The results were derived from a sample of only seven DHs per condition, which may restrict the statistical power of our study. Using different types of DHs means that various amounts of water could have been retained inside the pieces, which may represent a confounding factor. Additionally, all DHs were sterilized in the same autoclave, which may not guarantee consistent results across different autoclaves. Nonetheless, given that autoclaves adhere to standardized procedures and undergo regular checks and qualifications, it is reasonable to assume consistency in operation across brands. Future studies could be conducted on a larger number of DHs and various washers and sterilizers from different brands. Additionally, testing for microorganisms after autoclaving could be valuable to certify that the drying process, which appears to occur during the sterilization cycle, indeed ensures the compliance of this sterilization.

5. Conclusions

While sterilizing DHs between patients is standard practice, concerns may arise regarding the adequacy of their drying process pre-sterilization. Our study illustrates that autoclave treatment effectively eliminates residual water from within DHs, ensuring the necessary conditions for proper sterilization in terms of dryness.
Abbreviations

DH Dental handpiece
HIV Human Immunodeficiency Virus

References


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