

Improved Cleaning Method for Dental Instruments

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Received for publication Oct 15, 2010;
Accepted for publication Nov 9, 2010

• Abstract

We searched at the “PubMed.gov” and “jendodon.com” sites to conduct a literature review on dental instruments that are reused in clinical settings and on infection control involving pre-disinfection or sterilization cleaning/rinsing. The keyword “dental clean” was used for the Web search.

We found the present official definition of instrument cleaning performed prior to disinfection or sterilization rather limiting (“removal of foreign matter (soil, organism, etc.) from the instruments”). Thus, we proposed to expand the definition to include the removal of oils applied to protect the metallic instruments and from corrosion, stains, and rust resulting from the frequent reuse of the instruments. Clinicians are found to clean their dental instruments (a) immediately after treating their patients or (b) following their treatment but not immediately afterward. In the latter case, we recommend presoaking to be added. Ultrasonic sterilization of 5 ~ 15 minutes is found to be more effective in terms of eliminating residual matter from the instruments compared to other methods. To check on the cleaning results, we recommend visual inspection, which can be quick and practical in clinical settings. The latest products being developed and marketed on the market address the related problems. Nonetheless, research must be continued on the effects of presoak, cleaning/rinsing, disinfection, and high-temperature or heating-based sterilization on the dental instruments and on dental clinicians’ practices in cleaning, disinfection, and sterilization.

We advise dental clinicians to select the proper cleaning methods and detergents for their instruments to help eliminate or prevent corrosion, staining, and rusting, to reduce the maintenance costs, and to ensure user-friendly instruments/apparatuses.

• Key word : cleaning, dental instruments, presoaking, detergent cleaner, ultrasonic cleaner

• J Kor Dent Sci. 2010; 3(2) : 26 – 33

Introduction

In professional dental care, it is imperative that clinicians engage in infection control to help prevent and/or minimize the dental care team's exposure to germs while performing procedures and cross-contamination between patients. One way of ensuring thorough infection control is to use sterilized apparatuses during dental care. Conventional methods for infection control include immediate rinsing of the used apparatuses to ensure reuse or immersion-rinsing-sterilization series. Hu-Friedy, a US-based, world-renowned dental instrument manufacturer, advises dental clinicians to practice cyclical maintenance of their apparatuses/instruments that involves: (a) clinical use and maintenance; (b) inspection; (c) rinsing/ultrasonic cleaning; (d) sterilization, and; (e) sharpening¹⁾. However, metallic dental instruments undergo transformation in their physical properties (grinding efficiency, angular deflection, rigidity/flexibility, ease of maneuvering) as they are repeatedly exposed to cleaning agents, sterilizers, and anti-corrosive agents during clinical uses, rinsing, cleaning, and sterilization²⁾. Extensive post-surgical immersion, cleaning, and sterilization under a high-temperature, high-pressure condition using autoclave could reduce the likelihood of cross-contamination in dental apparatuses. However, careless maintenance of the instruments after use could lead to corrosion, stains, and rust. Thus, careful cleaning and maintenance of dental instruments are the key to extending the service life of the instruments, reducing the maintenance costs, and ensuring the convenience of the users (surgeons) performing procedures.

In Korea, infection control of dental apparatuses is carried out in accordance with the Criteria for the Infection Control of Dental Clinics³⁾ and Guidelines for the Used Instruments and Items of Medical Clinics⁴⁾. In particular, Article 5-1) ("Maintenance of Dental Instruments") of the infection control criteria requires that preuse treatment, storage, and pre-disinfection and sterilization be carried out by "thorough rinsing and cleaning to ensure the sterilization of the instruments used." Likewise, Article 2 ("Definition") of the used instruments and items of medical clinics guidelines states thus: "Cleaning refers to a process of eliminating any and all foreign matter

(organism, soil, etc.) from the target item." The clause also states that the most fundamental step of disinfection and sterilization normally involves the simultaneous use of water, mechanical friction, and detergent. The criteria and guidelines set forth by South Korea's Ministry of Health & Welfare (MHW) define the cleaning of dental instruments simply as the "removal of foreign matter (soil, organism, etc.)" and "thorough cleaning prior to sterilization." The definitions show where the focus of the legislation is and how limited it is, i.e., simple rinsing and cleaning of dental apparatuses.

Dental instruments are made of carbon steel or stainless steel; some of them come with resin-based handles. Carbon steel instruments with optimal level of rigidity can maintain the sharpness of their grinding edges, but they are more sensitive to chemicals and are vulnerable to corrosion; thus requiring special treatment. Stainless steel instruments are more vulnerable to discoloration and are corroded by certain chemicals, routinely requiring sharpening. Stainless steel apparatuses include those with grinding edges or blades that are capable of maintaining an appropriate level of rigidity and sharpness as well as those that are designed to be corrosion-resistant and with welded or soldered handles.

The carbon content in stainless steel alloys causes corrosion or rusting on stainless steel instruments that require rigidity and sharp blades/edges. Thus, manufacturers of dental instruments/apparatuses resort to passivation and electrolytic polishing to help reduce surface corrosion. Passivation creates a thin layer of chrome oxides on the surface of the instruments via chemical reaction and protects the metal with transparency and tensile strength. Thus, instruments treated with passivation will be better protected against corrosion. Electrolytic polishing⁵⁾, on the other hand, reduces corrosion by finishing the surfaces with high level of polishing and grinding.

Metallic resistance tests⁶⁻⁸⁾ in accordance with ISO 13402, which guides the manufacture of surgical and dental instruments, offer proper testing methods and evaluation means to manufacturers and users alike. The high-pressure sterilizer used in corrosion testing is also used to eliminate the chemical matter and contaminants remaining on the metallic surfaces. Based on the

corrosion test results, manufacturers are recommended to select proper metallic material processing methods, and users are advised to use and maintain the instruments with proper care.

Cleaning of dental instruments – which takes place prior to their disinfection or sterilization -- is undoubtedly crucial in maintaining the instruments, although care in actual dental fields (outpatient clinics and hospitals) was found to be somewhat neglected, and research on instrument-cleaning, insufficient at present. In this study, we examined the effects of dental instrument cleaning on the metallic products particularly on root canal instruments. We reviewed cleaning/rinsing, disinfection, and sterilization involved in dental instrument cleaning. In addition, we proposed a desirable definition of dental instrument cleaning and reported on cleaning methods, types of detergents, cleaning period, cleaning verification methods, effects of heating-based sterilization on the instruments, and cleaning/disinfection/sterilization practices.

Materials and methods

For the Internet-based data search, we visited “PubMed.gov” and “jendodon.com.” With the former, we scanned 552 papers published between 1965 and 2010 using the keyword “dental clean.” At least 11 of the 552 papers turned out to satisfy our research criteria. Using the “jendodon.com” site, we scanned 793 papers using the keyword “dental clean.” Among them, 16 papers satisfied our research criteria.

Results

1. Studies on the metals used in dental instruments

Dental apparatuses¹²⁻¹⁴⁾ made of stainless steel⁹⁾ and NiTi^{10,11)} were studied.

2. Cleaning methods

The cleaning methods we found include detergent-based presoaking, ultrasonic cleaning^{11,13,14)}, and mixed method

^{9,10,12)} using both the presoaking and ultrasonic cleaning methods successively. Murgel, et al (1990)¹⁵⁾ reported pre-sterilization cleaning using gauze and sponge and other cleaning methods based on ultrasonic apparatuses. Johnson, et al (1997)¹⁶⁾ examined ultrasonic cleaning methods that utilize enzyme cleaning agents prior to sterilization.

3. Methods of checking on cleaning status

To make sure thorough removal has been carried out on blood, proteins, and residual organic matter, various checking methods are being utilized such as visual inspection¹⁵⁾, bacterial culture¹⁶⁾, Van Gieson staining method^{9,11)}, optical microscopy¹³⁾, SEM examination¹⁹⁾, nuclear microscopy²⁰⁾, and mixed methods¹⁰⁾.

4. Effects of heating-based sterilization

Haikel, et al^{2,17)} studied the grinding efficiency of stainless steel instruments subjected to cleaning, disinfection, and sterilization, whereas Hilt, et al¹⁸⁾ examined the effects of frequency of sterilization and different types of sterilizers (chemical, pressurized) on the physical properties of stainless steel and Ni-Ti instruments. Alexandrou, et al¹⁹⁾ observed the surface roughness of dental instruments by using dry-heating sterilizers, with Valois, et al²⁰⁾ examining the roughness of Ni-Ti root-canal instruments by repeatedly sterilizing them via pressurized sterilizers.

5. Cleaning, disinfection, and sterilization practices

Bagg J, et al^{21,22)} studied dental clinics' practices in the instrument cleaning, processes, environment, and equipment used. Martin, M.V., et al²³⁾ examined water basin cleaning via pressurized sterilizers.

Discussion

Majority of dental instruments/apparatuses are made of stainless steel or carbon steel. When cleaning the instruments, rinsing, disinfection, and sterilization should be carried out by metal type. If cleaned, disinfected, or sterilized together, carbon steel instruments could cause cross-corrosion to their stainless steel counterparts. When

dealing with carbon steel instruments, make sure that they are completely dried prior to sterilization to help prevent rust or corrosion; rust-resistant solutions must be used prior to sterilization to ensure protection.

Frequent reuse of dental instruments contributes to corrosion, staining, and rust developing on the metallic instruments. Specifically, corrosion is further grouped into corrosion, tarnish, galvanic corrosion, pitting, and spotting.

- (1) Corrosion refers to an oxidation process wherein iron becomes iron oxides or rust. Oxidized metals feature low levels of energy and allow corrosion to occur. Corrosion is accelerated in a warm, wet environment such as inside the oral cavity and high-pressure sterilizers.
- (2) Tarnish means a chemical or an electrochemical attack on metallic surfaces. In case of repeated attacks, surface discoloration (“tarnish”) takes place, which leads to corrosion. As the tarnish continues to build layers on the surface, it protects the metal from the external environment and helps deter corrosion. The layers on metallic surfaces are in most cases transparent and are consequently invisible. Nevertheless, they coat the metallic surfaces and help stop surface corrosion from progressing further. Metallic instruments wherein the layers are not building up and the surfaces are not being protected will continue to develop corrosion and will undergo material loss as a result.
- (3) Galvanic corrosion is an electrochemical process that causes corrosion in a moisture-ridden environment; it is similar to the one that produces battery power. Corrosion takes place when more than two different metals come into contact with each other (such as in the case of carbon steel and stainless steel) or when a metal is exposed to two different environments that differ in terms of humidity, pH, oxygen concentration level, and chemical concentration level. With corrosion underway, the materials suffer loss, and the instruments undergo discoloration and loss of strength. The repeated exposure and progressing corrosion trigger rough attacks on the small area of the instruments and cause surface staining and pitting. The pit portion of the instrument contributes to

creating an environment with different pH and oxygen concentration level compared to other portions of the instrument, thereby increasing the degree of corrosion and encroaching into the core. To solve the problem, clinicians are advised to perform grinding on the pits and damaged surfaces to help alleviate the corrosion. Other methods for stopping corrosion include: (a) using precious metals to help prevent corrosion, which is impractical due to cost concerns, and; (b) letting the oxidized layer (protective film) build up on the metallic surface of the instruments, which is feasible with stainless steel apparatuses, to protect their surfaces from the external environment. However, the chromium oxides protecting the stainless steel are destroyed in solutions containing chloride ion. Thus, cleaning agents or disinfectants containing the ion must be rinsed off before sterilizing the stainless steel⁶. Clinicians are advised to take caution against cleaning products with residual chloride ion since they attack the protective film and cause corrosion, rust, tarnish, and pits on the instruments.

- (4) Pitting is known to attack the metallic surface chemically as well as electrically and cause localized corrosion. Methods for preventing pitting include: (a) thoroughly rinsing the instruments after use; (b) preventing instruments from prolonged exposure to chloride compounds and acids; (c) avoiding detergents with high pH levels, and; (d) avoiding putting different metals together inside the devices when using ultrasonic cleaning devices.
- (5) Spotting is caused by minerals penetrating and building up on the metallic surfaces when they are dried slowly or inappropriately. To help prevent spotting, clinicians are recommended to check on the operation of high-pressure sterilizers and to use chloride ion-free solutions for rinsing, cleaning, disinfection, and sterilization of the instruments.

Second, staining occurs when stains accumulate in the instruments through the high-pressure sterilizer’s contaminated water or when rust develops inside the alloyed metal. Identifying the cause of staining is crucial in eliminating the stains. In most cases, staining occurs during sterilization. Causes of staining include inappropriately maintained sterilization equipment,

contact between the instruments and the elements of detergents known to cause staining, and interaction between different types of metals taking place during cleaning or sterilization.

Next, rust is oxidized iron that is generated when iron or steel alloys (instruments) undergo corrosion. Rust is materialized in black, brown, or red. Severe rusting can form pits or blisters on the surface of the instruments, causing the surface to peel off in thin bits. Inadequate maintenance of the instruments will contribute to staining and pitting -- which are types of rust -- of the instruments, and rust will be accumulated on the surface as rust-dissolved water molecules cling to the surfaces and moisture evaporates. Actual examples show that the rust particles (solid form) floating inside the high-pressure sterilization tank accumulate on the instruments while sterilization is being performed. Thorough maintenance of the water tank/basin of high-pressure sterilizers can help prevent rust formation. Martin, M.V., et al²³⁾ reported on the importance of cleaning inside the water tank/basin of pressurized sterilizers and exchanging clean water inside the container via microbial or anti-toxic tests.

Given the aforesaid factors associated with the cleaning of the instruments, the current definition of pre-disinfection or sterilization cleaning of dental instruments/apparatuses as set forth by MHW ("Guidelines for the Used Instruments and Items of Medical Clinics") needs to be updated. The scope of the definition -- "removing foreign matter (organic matter, soil, etc.) from the instruments"-- should be expanded to include the removal of the oils applied to protect the metallic instruments as well as the corrosion, stains, and rust building up on the metallic surfaces due to frequent reuse.

Dental instrument detergents contain a single or more than two main ingredients. Depending on the main ingredient(s) of each product, the detergents are categorized into the following: (a) products containing protein-disintegrating enzymes; (b) detergents with rust-resistant components (anti-rust products); (c) products containing blood-eliminating components; (d) detergents containing rust-removing components, and; (e) products containing sterilizing/disinfecting ingredients²⁴⁾.

Detergents are marketed mostly in powder or liquid form and are used by diluting to achieve the concentration level

recommended by the manufacturers. The types of detergents available on the market are enzyme-based products capable of eliminating organic matter, oils, and rust as well as detergent-type products. Further examination and comparison are required to verify their respective cleaning power.

Methods of cleaning contaminated instruments as part of the pre-sterilization process include: (a) mechanically removing foreign matter from the instruments via running water and rubber-gloved hands or brushes; (b) presoaking the instruments for a period of time and chemically removing foreign matter via cleaning products that are either cleaning detergents or a combination of detergents and sterilizers; (c) performing ultrasonic cleaning followed by the mechanical removal of foreign matter, and; (d) subjecting instruments to ultrasonic sterilization using detergents or detergents combined with sterilizers and to mechanical as well as chemical elimination of foreign matter. Depending on the types of contact made between the instruments and the patient or the circumstances under which such contact is made, cleaning methods should be categorized and selected accordingly.

To observe the foreign matter-removing cleaning of dental instruments/apparatuses performed prior to disinfection or sterilization, Johnson, et al¹⁶⁾ soaked the instruments for 5 minutes before performing sterilization, subjected them to ultrasonic sterilization using enzyme-based detergents, and carried out pressurized or chemical sterilization on the instruments. Their examination of the growth of bacteria-contaminated matter showed that prior cleaning did not contribute to sterilization. In contrast, Haikel, et al¹⁷⁾ reported that the failure to remove bioburden from the instruments produces no sterilizing effects with certain sterilization methods.

Ultrasonic sterilizers were found to be more effective¹³⁾ in eliminating residual matter from instruments compared to dishwashers. Murgel, et al¹⁵⁾, Burkhart, et al¹⁴⁾, and Popovic, et al⁹⁾ reported on the outstanding elimination power of ultrasonic sterilization. Walker, N., et al (2006)¹²⁾ recommended an ultrasonic method that combines presoaking and cleaning, which adds presoaking to pre-sterilization cleaning. According to them, ultrasonic sterilization will produce stronger effects if performed between 7 to 15 minutes. Bagg, et al²²⁾

addressed the issues of most dental clinics performing manual cleaning that includes ultrasonic sterilization rather than automatic cleaning/sterilization and only a small number of manual cleaners actually using detergents. They were found to replace ultrasonic detergents every 9 hours (median).

Clinicians may clean their dental instruments (a) immediately after treating their patients or (b) following their treatment but not immediately afterward. In the case of the former, clinicians should perform cleaning (preferably ultrasonic cleaning) prior to disinfection or sterilization by using non-corrosive, foam-minimizing detergents. Enzyme-based detergents are used specifically to clean surgical and periodontal instruments because of their ability to disintegrate blood proteins, tissues, and residual matter promptly compared to other types of detergents. These types of detergents help reduce hand-scrubbing as well as infection resulting from detergent debris and damage to the hands. Note that using phenol, glutaraldehyde, or iodophors is prohibited for instruments with resin handle. As for post-treatment instrument cleaning that is not immediate, dental apparatuses must be immersed in solutions first. The lack of instant cleaning will lead to the buildup of dried residual matter on the instrument surfaces and to staining and improper sterilization. The presoaking solutions must fully cover the instruments.

The results of the cleaning are checked via visual inspection, Van Gieson staining method, and SEM examination to ensure the thorough removal of proteins and organic residual matter. Dental mirrors must be subjected to high-pressure steam sterilization for 5 times, with each test lasting 3 minutes (134 °C ~ 138 °C; 0.22 MN/m²) in accordance with KS (Korean industrial standard) P 7414, Korea Food & Drug Administration Notice No. 2005-17, and ISO Standard No. 9873. Visual inspection is utilized to determine the thoroughness of the cleaning by examining the mirror, cover, and handle for the presence of flaw, defect, disintegration, corrosion, etc. In clinical settings rather than research settings, visual inspection is recommended to ensure the prompt confirmation of the cleaning results.

Haikel, et al¹⁷⁾ and Haikel, et al²⁾ reported in their examinations of dental instruments subjected to cleaning,

disinfection, and sterilization that sterilization by heating of stainless steel and NiTi root-canal instruments does not affect the instruments' grinding efficiency, and that the efficiency decreases over time and according to frequency. Hilt, et al¹⁸⁾ reported that sterilization frequency and types of sterilizing devices (chemical, pressurized) do not necessarily affect the stainless steel/Ni-Ti instruments' microscopic structure, rigidity, or torsional strength. On the other hand, Alexandrou, et al¹⁹⁾ (dry-heating sterilizer) and Valois, et al²⁰⁾ (high-pressure sterilizer) separately reported an increase in the surface roughness of Ni-Ti root canal instruments after repeatedly sterilizing them and comparing the roughness with that of apparatuses that did not undergo repeated sterilization. Nowadays, electrolytic polishing-treated⁶⁾ root canal instruments designed to help reduce the roughness and defects found on the surfaces of the instruments are available on the market.

To ensure thorough infection control by dental clinics and hospitals, clinicians are advised to perform cleaning/rinsing, disinfection, and sterilization on their dental instruments/apparatuses in between treating patients. Routine visual inspection is the recommended method for checking the results. Instruments must be disposed of or repaired if they show signs of aging, corrosion, pitting, discoloration, bending or breakage, loosened or cracked handles, dull or over-sharpened blades/edges, and/or damaged blades/edges.

Moreover, clinicians are advised to pay attention to cleaning high-pressure gas containers (particularly those used to charge anesthetic gases) used with patients and maintained in accordance with Article 2 of the High-Pressure Gas Safety Control Act. Thorough cleaning of the inside of such containers will help prevent malpractice related to high-pressure anesthesia caused by the lack of thorough cleaning.

Conclusion

We examined the dental instrument cleaning being practiced in dental clinical settings. Cleaning aims at reusing dental instruments/apparatuses by performing infection control of the instruments prior to disinfection or

sterilization. The keyword “dental clean” was used to search Internet-based literature in sites such as “PubMed.gov” and “jendodon.com.” The search led to the results summarized below.

1. As clinicians carry out disinfection or sterilization, they must first clean/rinse the instruments as a pre-disinfection or a sterilization process. Currently, clinicians tend to define such cleaning/rinsing simply as “removing foreign matter (organic matter, soil, etc.) from the instruments.” Cleaning/Rinsing should be defined as a process aiming at cleaning the used dental instruments, eliminating the oils applied to the metallic instruments prior to disinfection or sterilization to protect them, and removing corrosion, staining, and rust from the metallic apparatuses resulting from frequent reuse.
2. Dental instruments can be cleaned either (a) immediately after treating patients or (b) after treating patients but not immediately. For the latter, presoaking must be added to the cleaning process.
3. For a proper cleaning method, clinicians should use ultrasonic cleaning since it outperforms other methods in terms of removing residual matter from the instruments. Ultrasonic cleaning should last 5 ~ 15 minutes²⁴. Cleaning agents must be able to eliminate organic matter, oils, and rust. Some of the products on the market have metal-whitening properties as well.

4. A recommended method for checking the cleaning status of the instruments is visual inspection, which is quick and easy to use in clinical settings.
5. Products are being improved continually to address related problems. Thus, clinicians are advised to continue monitoring the effects of instruments cleaned via heating-based sterilization and practices in cleaning, disinfection, and sterilization.

Based on our literature review, ultrasonic cleaning is a recommended form of dental instrument-cleaning method wherein presoaking is added to and made available for pre-disinfection or sterilization rinsing. In selecting detergents for ultrasonic cleaning, various factors must be taken into account: prices of the detergents; abilities to remove residual matter from the instruments; effects on metallic instruments; abilities to remove blood, disintegrate proteins, remove oils, and eliminate and prevent corrosion/staining/rust; effects of metal-whitening; cleaning of metallic portions of the sink, and; abilities to eliminate residual matter inside the drainage (except for calcined gypsum)^{25,26}. Dental clinicians are recommended to select the proper instrument-cleaning methods and detergents to eliminate and prevent corrosion, stains, and rust thoroughly, to reduce maintenance costs, and to ensure the availability of the user-friendliest instruments.

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