Review Article

Sterilization and orthodontics: A literature review

ABSTRACT

Sterilization is a process by which an article, surface or medium is freed of all microorganisms either in vegetative or spore state. On a daily basis, the practicing dentist and his personal are at risk of being exposed to wide patients with blood borne diseases such as HIV/AIDS, hepatitis B, C, and airborne diseases such as tuberculosis. Infection can be directly transmitted by oral fluids, blood, contaminated instruments and surfaces, or through the respiratory system. Control of infection that spreads through various instruments and armamentarium used in the field of orthodontics and dentistry in general is of utmost importance as a preventive measure for cross infection. Considering the fact that the rate at which newer strains evolve with time and older strains develop resistance, it has become a constant challenge through time and in the years to come. This article tells about various methods of sterilization by focusing on the guidelines for an effective and efficient orthodontic practice.

Keywords: Armamentarium, blood, blood borne, contaminated, cross infection, effective, microorganism, new stain, older stain, oral fluids, spore, sterilization, vegetative

INTRODUCTION

Sterilization is a process by which an article, surface or medium is freed of all microorganisms either in vegetative or spore state. Considering the enormity of challenge that infectious agents pose against us, as well as their nature to continuously evolve in real time, the implementation and execution of effective infection control protocols among all health-care communities including our own are vital. Against this backdrop, an appraisal of the current sterilization protocols from an orthodontic perspective is outlined so that it would facilitate the discerning orthodontist in us to make an informed decision toward their implementation. To accomplish infection control accurately and to reduce the risk of cross contamination, all patients have to be treated while practicing universal precautions, the latter including the imperative steps of disinfection and sterilization. According to Starnbach in 1988, orthodontists have the second highest incidence of hepatitis B among dental workers (Starnbach 1988). Saliva is the most common modes of transmission in dental offices through puncture wounds, skin abrasions, or lesions. Dental aerosols, splattering, and instrument contamination can also transmit the virus, which can survive for several weeks at room temperature.[1]

Sterilization in orthodontics has been discussed and stressed through times in the dental literature. Both patients and practitioners produce a substantial risk of spread of infection such as hepatitis B, pneumonia, and HIV because of the nature of oral environment which is rich in diverse aerobic and anaerobic bacterial flora. In a survey conducted on the various specialty practitioners of the dental faculty, based on the risk of contracting hepatitis, the orthodontists were the second highest among the group in contracting hepatitis. Sterilization, asepsis, and universal precautions to prevent infectious disease transmission are often neglected in dental

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practice. Hence, this article reviews the various sterilization protocols pertaining to orthodontic instruments apart from the implementation of additional infection control measures required in general.[2]

Some orthodontic instruments used regularly have hinges and cutting edges, and this makes disinfection before sterilization a sensitive procedure. Considering this of the challenge that infectious agents pose against us, as well as their nature to continuously evolve in real time, the implementation and execution of effective infection control protocols among all health-care communities are vital.

The advice sheet on infection control formulated by the Department of Health, United Kingdom proposed a three stage protocol to sterilization which includes presterilization cleaning, sterilization, and storage.[3]

STERILIZATION TECHNIQUES

Presterilization cleaning

The process involves debridement of all instruments contaminated with blood, saliva, and other impurities before undergoing a sterilization process. It is generally done by hand washing the instruments using detergents and brushes. However, in recent times, ultrasonic baths and instrument washer equipment have also been employed. Depending on the instrument load, this procedure lasts between 10 and 20 min. At the end of presterilization procedure, it is very important to eliminate any residual moisture on the instruments as it may lead to corrosion when certain types of sterilization procedures are employed in the next stage.[4]

Dry-heat sterilization

Dry heat causes destructive oxidation of constituents, denaturation of bacterial protein, and oxidative damage and toxic effects on bacterial cell. Moist heat sterilization causes denaturation and coagulation of bacterial enzyme protein. The dry-heat sterilization (DHS) and clinical recycling (CR) produce significant changes in the loading and unloading characteristics of nickel-titanium (NiTi) wires. CR reduces the "pseudoplasticity" of NiTi wires and increases its stiffness (Kapila, 1992). A study conducted to compare the nickel ion concentrations released from recycled NiTi wires after sterilization by either dry heat or steam autoclave showed no significant differences in the nickel ion concentrations released into the saliva (Poosti *et al*., 2009). Similarly, another study conducted to compare the wear of orthodontic ligature cutting pliers after multiple cycles of cutting stainless steel ligature wire (0.025 mm) and sterilizing with dry heat or steam autoclave showed no significant difference in the mean wear at the tip of the pliers concluding that there is no need to maintain both sterilization systems, dry heat and steam autoclave, in the orthodontic office. Steam autoclave sterilization can be used with no deleterious effects on the pliers if they are manufactured with good quality stainless steel inserts. The absence of moisture is of utmost importance for the longevity of the pliers (Rapisarda *et al*., 1999). Hot air oven is the most widely used method of sterilization by dry heat. A holding period of 160°C (320°F) for 1 h is used to sterilize glassware, forceps, scissors, scalpels, all glass syringes, swabs, liquid paraffin, dusting powder, fats, and grease. Present day hot air sterilization involves cycles at 190°C for 6-12 min and is also called as rapid DHS. Studies have concluded that neither the heat sterilization nor multiple cycling procedures had a deleterious effect on the elastic moduli, surface topography, or tensile properties of nitinol or titanium archwire.[5]

Flaming

Tips of the instruments are held in a Bunsen flame till they become red hot. These include inoculating loop of wires, points of forceps, and searing spatulas. Materials may be dipped in a disinfectant before flaming. Articles are passed for a few seconds without letting them get red hot which include scalpels, needles, mouth of culture tubes, glass slides, and cover slips.[6]

Hot air oven

Is the most widely used method of sterilization by dry heat. A holding period of 160°C (320°F) for 1 h is used to sterilize glassware, forceps, scissors, scalpels, all glass syringes, swabs, liquid paraffin, dusting powder, fats, and grease. Present day hot air sterilization involves cycles at 190°C 6–12 min and is also called as rapid DHS. It is suitable for dry powders and water free oily substance. This type of energy does not penetrate materials easily and thus long periods of exposure to high temperatures are necessary. It is an effective and safe method of sterilization for metal instruments such as pliers and mirrors as it does not cause corrosion of carbon steel instruments and burs.[7]

Glass bead sterilizer

The glass bead sterilizer uses a metal cup with glass beads of 1.2–1.5 mm in diameter. Larger beads are not effective in transferring heat to due to presence of large air spaces between the beads which reduces the efficiency of the sterilizer when operated at a temperature range of 218°C–240°C for 3–5 s. The use of this method in orthodontics is limited to orthodontic bands. However, it is theoretically possible to sterilize one or two pliers within 20–30 s. A longer sterilization time is required because larger the instrument longer the heat-up time. Similarly, if more than one molar band at a time is placed in the well, twice the amount of time is required. The recommended protocol for sterilization of single molar band to have a sporicidal effect is 220°C for 45 s.[8]

Autoclaving

Autoclaving is the most popular method of sterilization and is considered as a gold standard for sterilization procedures. The basic principle is that when the pressure inside a closed chamber increases, the temperature at which water boils also increases. It liberates 518 calories of heat. *Bacillus stearothermophilus* is used for testing the efficiency. As the water molecules in steam become more energized, their penetration also increases. It is used for heat resistant plastics, dental handpieces, dental instruments, cotton rolls, gauze, anesthetic syringes, glass slab, and towel packs. The conventional method involves pressure in the range of 15–20 psi at a temperature of 121°C–134°C (250°F). A holding time of 15–21 min at 121°C (conventional method) or 3 min at 134°C (rapid cycle) is required for proper sterilization. The complete cycle from the start of sterilization to subsequent cooling requires 45 min to 1 h. Although it is the most popular method of sterilization the presence of steam vapor during the process of heating has detrimental effect on the orthodontic pliers in the form of rusting and corrosion. However, a study conducted by Vendrell *et al.* on orthodontic ligature-cutting pliers with stainless steel inserts showed no significant difference in mean wear whether sterilized with steam autoclave or dry heat. Steam autoclave sterilization can be used with no significant deleterious effects on pliers with stainless steel inserts. The sterilization procedures which included steam autoclave, dry heat, or cold solution sterilization showed no clinically significant differences between new and used archwires. A lot of attention has been focused on sterilization of molar bands for both the tried-in bands as well as the new bands. It is recommended to sterilize the tried-in molar bands separately without mixing them up with the new ones. If the tried-in molar bands cannot be sterilized immediately, it is advisable to process them through a presterilization cleaning procedure with ultrasonic scaling and storing them separately.[9]

Ethylene oxide sterilization

Ethylene oxide is a gas at temperatures above 10.8°C. It has excellent penetration capacity and is sporicidal as well as virocidal. It is both the toxic and highly explosive. The gas is released into tightly sealed chamber where it circulates for up to 4 h which is carefully controlled with humidity and mixed with CO_2 and nitrogen to reduce concentration of up to 10% so that it is less explosive. The chamber then should be flushed with inert gas for 8–12 h to ensure that all traces of ethylene oxide are removed. Otherwise, the chemical can cause "cold burns" on contact. It is used to sterilize paper, leather, wood, metal, and rubber as well as plastic. The conventional orthodontic marking pencils cannot be autoclaved. Gas sterilization is effective in killing bacteria but is also costly and difficult, making it impractical for orthodontic offices.[10]

Chemical immersion/cold sterilization

This method is recommended only for heat sensitive nonsurgical instruments and alginate impressions. One of the facts about cold sterilization is that there is no method to verify its effectiveness. Nearly 2% glutaraldehyde is the most popular high-level disinfectants used in dentistry. It is a colorless liquid with a pungent odor. It is very effective method of inactivation of bacterial spores. Studies have shown that spore is permeable to glutaraldehyde regardless of pH and temperature and that chemical penetrates the spore at once. It is used as an as immersion solution for metallic instruments, face masks, heat sensitive plastic rubbers, and fiber optics. The duration of sterilization is about 6–10 h at room temperature. It is noncorrosive and nontoxic and can sterilize heat-sensitive equipment. An added advantage is its low cost. Long immersion time, odor, irritating to mucous membrane (eyes), and monitoring are a relative disadvantage. This method can be employed on elastomeric materials such as elastomeric modules by cutting them into smaller sections and covering them with clear tubing, which could then be cold sterilized. Studies comparing the various sterilization protocols have revealed that cold sterilization causes a pitting type of corrosion of orthodontic instruments as against surface corrosion caused by other methods. A method to sterilize plastic items and heat sterilizable cheek retractors by immersing them in procide (sterilization solution which turns milky) after autoclaving and there by optimizing the sterilization technique has been followed.[11]

Alcohol is an effective skin antiseptic and valuable disinfectant for medical instruments. Ethyl and isopropyl alcohol are most frequently used. Isopropyl alcohol is preferred to ethyl alcohol as it is a better fat solvent, more bactericidal and less volatile. It is active at a concentration of 50%–70%. It denatures proteins and lipids and leads to cell membrane disintegration. It is also a strong dehydrating agent. It is used to sterilize the skin before cutaneous injections. It is commonly used for disinfection of clinical thermometers. "Isopropyl alcohol" has high bactericidal activity in concentration as high as 99% but is relatively inefficient in the presence of blood and saliva. It lacks sporicidal activity and also causes corrosion of metals. It has been used for sterilization of orthodontic archwire materials for recycling. Studies concluded that neither the heat sterilization nor multiple cycling procedures had a deleterious effect on the elastic moduli, surface topography, or tensile properties of nitinol or titanium archwire.

Surface active agents are substances which alter the energy relationships at interfaces producing a reduction of surface tension. They are widely used as wetting agents, detergents as they possesses both water attracting (hydrophilic) and water repelling (hydrophobic) properties. A classic example is an anionic surface active agent (soap). There is a greater compliance with sterilization recommendations including protective barriers among general dentists than orthodontists.[12]

Laser (light amplification by stimulated emission of radiation)

Recent experiments indicate that laser beams not only sterilize instruments14 but also the air in operating rooms, as well as wound surfaces. Various types of lasers used include CO_2, Argon, and neodymium-doped yttrium aluminum garnet lasers. The cost factor has been the primary reason for its uncommon use.

Sterilization and disinfection of orthodontic instruments and material

Orthodontists generally do not make very intensive operations on tissues and they do not treat infectious diseases. Despite this, however, patients can carry germs that may infect other people. The use of proper sterilization techniques is important today because of the professional, ethical, and legal aspects.

Sterilization of orthodontic pliers

Before DHS, if water drops or excess disinfectant is left on the pliers, they can be severely damaged. Corrosion of these instruments is one of the few sterilization consequences that orthodontists face. To prevent corrosion, orthodontic pliers should be dried with pressured air before sterilization. If they are not dried well, ions' reaction will create a loose layer of rust. Corrosion can also be prevented by oiling the joint surfaces with appropriate solutions.

Autoclaving will negatively affect orthodontic instruments causing blunting and corrosion of their sharp cutting edges. Moreover, one of its major disadvantages is that it is time consuming. Hence, soaking in 1% sodium nitrate can be recommended as an alternative. Glass bead sterilization is another viable method in which pliers are left inside the sterilizer at 218°C (450°F) for 15 seconds only. Note that, large instruments cannot be sterilized with this method. A successful high level disinfection can be obtained using an ultrasonic bath (Sekusept 5%).[13]

Disinfection of orthodontic brackets

Chlorhexidine is an appropriate disinfectant to be used on metal or ceramic brackets. In a study that evaluated the effect of 0.01% chlorhexidine solution on metal and ceramic brackets, it was found that chlorhexidine does not have a significant effect on the metal brackets' adhesion ability (Kapila, 1995). On the other hand, the attachment ability of ceramic brackets is significantly affected from this disinfecting solution, but the clinical effect does not reach levels below 6–8 Mpa.[14]

Decontamination of orthodontic bands

Stainless steel bands of various sizes are frequently used on molars during fixed orthodontic treatment. Choosing the appropriate size requires often several trials. If trying of the bands is attempted inside the patient's mouth and determined that the size is not appropriate, the band should be decontaminated from saliva and blood, and autoclaved for future use.

Sterilization of orthodontic wires

The studies on the effect of sterilization on orthodontic wires have been going on since the 1980s. The results are in contradiction with one another. Some of the studies report mechanical alterations whereas the others defend the opposite (Buckthal, 1986). Pernier *et al.* (2005) observed the sterilization of 6 different archwires by autoclaving them for 18 min in 134°C through surface analysis techniques. No significant change was observed on the alloys surface characteristics that would affect their utilization.[15]

Disinfection of elastomeric ligatures

Polyurethane elastomers are frequently used in orthodontics as ligature and chains. The unused parts of elastomeric ligatures are generally sterilized through cold sterilization since they are not heat resistant. Various studies showed that repeated disinfection of the same elastic can accelerate the destruction of the cross-links available in the long chain molecules of polyurethane polyesters. Sterilization of elastomeric ligatures inside the autoclave at 121°C does not lead to permanent deformations or to increased shrinkage whereas in the case of dry-heat, their manipulation becomes more difficult.

Bacterial contamination and disinfection of removable acrylic appliances

When using removable appliances, there is an excessive formation of a biofilm layer that is observed on the retentive areas of hooks and springs and on the smooth acrylic surfaces of the appliance. Studies showed that *Lactobacillus* and *Streptococcus mutans* levels are increased inside dental biofilm as a result of changing oral microflora during orthodontic therapy with active removable appliances. Toothbrushes were not efficient enough to remove the microorganisms on the retentive areas of the appliances. Hence, it is recommended to use antimicrobial agents to eliminate the bacterial biofilm. Disinfection methods of acrylic orthodontic appliances should inactivate pathogenic microorganisms immediately, without damaging the composition of the appliance. Soaking the appliance in a chemical solution could cause decomposition of the acrylic resin molecules. In Lessa *et al.*'s study, chlorhexidine gluconate, cetylpyridinium chloride, and sterile water were compared in terms of their eliminating action on *Streptococcus mutans*. Antimicrobial solutions in spray form were used, and they were examined for causing any changes in the composition of acrylic or not. The results of this study suggested that both of the previously mentioned antimicrobial agents reduced contamination compared to sterile water, but chlorhexidine gluconate was found to be significantly more effective than cetylpyridinium chloride.[16]

DISCUSSION

One of the most important points to debate on as far as sterilization is concerned is the instrument damage caused in spite of proper sterilization protocol. The factors that influence instrument damage include the water quality, use of strong detergents, excessive heat exposure, and presence of moisture after presterilization cleaning, improper compositions, and concentrations of chemicals used and last but not the least the quality of pliers. It may be more appropriate to categorize the materials used in orthodontics under the following headings and discuss the practical guidelines for an effective process of sterilization:

Orthodontic plier sterilization:
1. Ultrasonic scaling for 5–12 min
2. Rinsing it with distilled water
3. Remove the excess moisture
4. Lubricate the joints with silicone-based lubricants
5. Sterilize using dry heat or Autoclave (as recommended).

Molar bands:
1. Ultrasonic scaling for 5–12 min
2. Rinsing it with distilled water
3. Remove the excess moisture
4. Sterilize using dry heat or autoclave (as recommended)
5. Chemical immersion protocols should be limited to bands without prewelded attachments
6. Glass bead sterilization is only an option.

Elastomeric ligatures and chains

Chemical disinfection is not recommended for elastomeric chains and ligatures as they are known to destabilize their physical characteristics. However, elastomeric modules can be sterilized by cutting them into smaller sections and covering them with clear tubing, which could then be cold sterilized.

Alginate impression

Commonly used disinfecting solutions used for alginate impressions are 2% glutaraldehyde and 1% sodium hypochlorite. The manufacturer's prescription recommends immersing the alginate impression for not more than 10 min as it may cause alteration in the surface characteristics of the material. Newer alginate impression materials are commercially available as self-disinfecting alginates.
1. Rinse the impression under running water on removal from the oral cavity
2. Immerse them in disinfecting solution for 7–8 min (not more than 10 min)
3. Clean under running water to remove the disinfecting solution
4. Pour the model.

CONCLUSION

It is incumbent on each orthodontist to conduct their practice in a manner that restricts the spread of infection and cross contamination. The presence of transmissible diseases like HIV/AIDS and hepatitis B and C make it an absolute necessity to protect clinic staff and patients from cross contamination, using effective disinfection and sterilization techniques. As the age old saying "prevention is better than cure" goes, thorough understanding of the application of the sterilization will help ensure safety from the invisible but deadly world of microbial pathogens. Hence, utilization of proper sterilization, disinfectants, and aseptic procedures will help us achieve the safety of our professional demands.

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Conflicts of interest

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