Sterilization in Endodontics : A newer concept

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Abstract

The endodontic procedure involves several steps, including isolating the tooth using a rubber dam, creating an access cavity with burs, cleaning and shaping the canal, and compactly obturating the canal. Throughout each phase, sterilization of instruments is essential to prevent blood-borne diseases such as HIV, Hepatitis B, and other infections. Proper understanding and adherence to sterilization protocols at every stage are crucial for effective infection control. Sterilization involves the complete removal of microorganisms and spores from treated surfaces, with autoclave-based heat sterilization being the most commonly used method. Before the invention of the autoclave, the dry heat method was widely employed in dentistry. This review highlights the various sterilization methods used in endodontics.

Keywords

Sterilization; Infection; Control; Blood; Endodontics

Introduction

One of the major causes of cross-infection in dental clinics is improper handling and sterilization of instruments. Infection control plays a crucial role in delivering comprehensive dental care. A key concern is preventing cross-contamination between dental staff and patients due to contaminated instruments. Blood and saliva are primary carriers of infections such as Hepatitis B, HIV, and other blood-borne diseases. Since endodontic procedures often involve blood contamination, it is essential to sterilize all instruments, including both rotary and hand files, after each patient. Sterilization is the process that eliminates bacteria and ensures a safe clinical environment. Different microorganisms, both pathogenic and non-pathogenic, can exist in either vegetative or spore form on the surface of materials intended for sterilization. A sterile item is one that is completely free from living microorganisms.

Chemical sterilization is used for thermosensitive instruments that cannot withstand moist heat sterilization. However, instruments that are not thermosensitive can be sterilized using an autoclave, which is the standard method for sterilizing all instruments in a dental clinic.Ensuring the complete elimination of microorganisms after sterilization is crucial. Therefore, regular quality management is an essential part of the sterilization process. To verify the effectiveness of sterilization, biological indicators such as spore strips are used. These strips change color after sterilization if the autoclave is functioning properly, confirming its ability to eliminate bacteria.Proper sterilization of instruments used in dental procedures helps prevent cross-contamination. If instruments are not adequately sterilized, they may contribute to the spread of infections. Common sterilization methods include autoclaving, ethylene oxide gas sterilization, glass bead sterilization, and dry heat sterilization. Additionally, chemical disinfectants exhibit bactericidal effects, aiding in microbial control. Microorganisms can be eliminated after 15 minutes of exposure to chemical disinfectants; however, these disinfectants are not effective against spores and viruses. The autoclave is the most commonly used method for sterilization due to its efficiency in a short period.

Critical instruments, which are those that penetrate soft tissue and bone, must be thoroughly sterilized after each use to ensure patient safety and prevent infection.

Difference between disinfection & sterilization

Understanding the difference between disinfection and sterilization is essential, as both procedures eliminate pathogens from treated surfaces. Disinfection removes pathogens but leaves spores intact, whereas sterilization eliminates both pathogens and spores, ensuring complete microbial eradication.

Cleansing & Disinfection (Presterilization)

After completing treatment, the first step in the sterilization process is to remove blood and debris from endodontic instruments. The debris typically consists of proteins, blood residue, and dentinal shavings. This cleaning can be done manually using disinfectant liquids or with an ultrasonic washer. The ultrasonic method is considered more effective than manual washing, as it can break down organic components more efficiently.

A study by Sureshchandra et al. compared different cleaning and disinfection methods using three materials: 3% hydrogen peroxide, manual brushing, and 70% alcohol. In a test group, they used manual brushing with 1% sodium hypochlorite followed by an ultrasonic bath. The results showed that the test group was more effective at cleaning. Similarly, research by Azarpazhooh et al. demonstrated that ultrasonic cleaning is highly effective in cleaning endodontic instruments.

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Disinfection of Root Canal Filling Materials:

Materials used for sealing root canals include gutta-percha (GP). Before inserting the GP points into the canal, they are typically sterilized by dipping them in a 5% sodium hypochlorite solution. Gutta-percha cones contain zinc, which helps prevent bacterial adhesion to some extent. Research indicates that during the manufacturing process, approximately 30% of GP samples may be contaminated with bacteria, such as Staphylococcus spp. If the GP point passes through the apical foramen, there is a higher risk of infection if it isn't sterilized prior to placement. Since sterilization via heat can alter the cone’s size and shape, autoclaving is not recommended. Alternatives include sterilization with sodium hypochlorite in concentrations ranging from 0.5% to 5%, chlorhexidine (2%), or hydrogen peroxide 3%.

Sodium Hypochlorite and Chlorhexidine

A 5% sodium hypochlorite solution was used for sterilizing the cones. One of the primary side effects is its corrosive impact on most endodontic instruments. Rutala et al. demonstrated through SEM scans that both solutions can reduce tensile strength after the cone is immersed for 10 minutes. Eldik et al. found that a 5-minute treatment with 5% sodium hypochlorite is one of the most effective methods for reducing bacterial contamination on the surface of gutta-percha points.

Sterilization of Endodontic Instruments: After cleaning instruments through hand washing or ultrasonic cleaning, all instruments should be dried and wrapped. The most commonly used sterilization methods over the past twenty years include autoclaving, glass bead sterilization (45 seconds at 240°C), UV lights, laser sterilization, and glutaraldehyde. Many studies have shown that autoclaving effectively eliminates bacteria, spores, and viruses at 121°C for 15 minutes for endodontic instruments. UV sterilization works by using thermal heat to activate nucleic acids, inducing thymine dimers. However, UV light only works on surfaces directly exposed to it. A 2% glutaraldehyde solution is another effective sterilization method for endodontic and other dental instruments, though it is highly toxic and requires 12 hours to sterilize, which is impractical in clinical settings. Laser sterilization, particularly with CO_2 lasers, has been used as a chairside tool for reamers, with studies showing successful sterilization using argon lasers. However, research suggests that autoclaving rotary instruments can cause fractures during root canal preparation due to cyclic fatigue. To mitigate the risk of fractures, 6% hypochlorite has been used to reduce microbial contamination.

Burs: Decontamination and Sterilization:

Diamond burs used in the endodontic process for removing caries and preparing the initial access cavity should be placed in an ultrasonic bath for 15 minutes after use. Following this, they can be autoclaved to prevent cross-infection to other patients.

Endodontic files

Hand operated endodontic files

Most hand files are typically considered single-use items. Sterilizing them is ineffective and unsafe, as it can lead to sharps injuries. While there are effective protocols for cleaning rotary nickel-titanium files, they have limited success in removing bioburden from hand files made of stainless steel or nickel-titanium alloy. Moreover, the complex design of endodontic files, with microscopic crevices created during manufacturing, traps debris to which prions can adhere, making them resistant to most decontamination and sterilization methods. Prions are highly heat-resistant and can cause neurodegenerative disorders. According to WHO guidelines, inactivating prions involves immersing instruments in sodium hypochlorite (20,000 ppm chlorine) for one hour, heating with 1 M sodium hydroxide for one hour, or autoclaving at 121°C under vacuum for 30–90 minutes with sodium hydroxide. However, these procedures are unsuitable for endodontic files as they can cause corrosion and damage the instruments' mechanical properties, and the required timing is impractical for outpatient use. Therefore, it is recommended that hand files should not be reused whenever possible. The UK Department of Health also advised in 2007 that endodontic files should not be reused.Hand files should be considered disposable instruments, or at least the most effective sterilization methods available should be used. While single-use hand files remain the preferred choice, several studies have compared different sterilization and disinfection protocols for reusing them. These studies conclude that proper disinfection followed by autoclaving remains the most effective method compared to alternatives like hot air ovens, glass bead sterilization, ultrasonic cleaners, chemiclave, and various chemical disinfectants.

Studies also show that although glass bead and salt sterilizers are designed for this purpose and require less time, they do not effectively sterilize files. This is because they rely on dry heat sterilization, which has poor penetration. Additionally, the handle portion of the files often remains unsterilized. Using an endodontic box instead of plastic packaging for autoclaving has shown marginally better results.

A study also suggests that enzymatic disinfection, where the files are immersed in an enzymatic disinfecting solution in an ultrasonic bath before autoclaving, is highly effective. Enzymatic solutions contain proteinases and collagenases that help break down pulpal tissue adhering to the files. Moreover, mechanical debridement (scrubbing) with an appropriate brush and soap water before immersion in a disinfecting solution and autoclaving is essential for removing the bulk of the pulpal tissue.

Rotary NiTi files

It is not cost-effective to discard rotary files after a single use. Additionally, sterilizing NiTi files is more effective than sterilizing stainless steel files due to differences in surface characteristics. However, the physical and mechanical properties of NiTi instruments are only partially restored after autoclaving. As such, it is recommended that NiTi files be used for no more than five cycles.

When reprocessing NiTi endodontic rotary files, the cleaning process before sterilization must be validated for effectiveness. Below is a verifiable cleaning process:

1. Immediately after use, remove the stoppers and place the files in a scouring sponge soaked in an aqueous solution of chlorhexidine gluconate.
2. Clean the files by making 10 vigorous in-and-out strokes in the sponge.
3. Place the files in a wire mesh basket and immerse them in the appropriate disinfectant solution.

A suitable enzymatic cleaning solution should be used for 30 minutes,
4.Followed by 15 minutes of ultrasonification in the same solution.
5.Afterward, the files should be drained and rinsed under running water for 20 seconds before proceeding with steam sterilization.

The adverse effects of sterilization and disinfection on NiTi files can be summarized as follows:

1. Disinfecting agents like sodium hypochlorite and autoclaving can increase the surface roughness of the metal and cause micropitting corrosion.

2. There is a reduction in the cutting efficacy of NiTi files, especially in alloys not treated during the manufacturing process (e.g., twisted files with M-wire alloy). Research has shown that corrosion from autoclaving reduces the cutting capacity by 20% after seven autoclave cycles, and by 1%-12% after 5-10 cycles.

3. NiTi instruments experience partial recovery of cyclic fatigue when autoclaved (though not in all studies). Recently, manufacturers have produced superelastic NiTi alloys through a thermomechanical process that maintains a stable martensitic phase during use, allowing for additional thermal treatment during sterilization to enhance flexibility.

4. The impact of autoclaving on torsional stress (resistance) has produced varying results. Some studies suggest autoclaving improves resistance, while others indicate no effect or potential harm

Given these effects, it is evident that while rotary endodontic instruments are reusable, their reuse should be limited to a few autoclave cycles to ensure clinical efficacy and reduce the risk of instrument separation.

Changes in the Physical and Mechanical Properties of Endodontic Instruments Subject to the Sterilization Process:

Cyclic Fatigue and Torsional Stress:

One of the main causes of endodontic instrument fracture is cyclic fatigue during root canal treatment. The instrument undergoes cyclic stress followed by compressive loading, which leads to fractures. The likelihood of fracture increases with more cycles. Another type of stress is torsional stress, which occurs when the instrument rotates completely inside the canal, leading to fracture, especially in areas where the canal is blocked or calcified. To address these issues, NiTi files have evolved to include shape memory, which helps improve their flexibility and resistance to fatigue.

Roughness, Corrosion, and Reduction of Cutting :

Roughness and corrosion of NiTi instruments during irrigation with sodium hypochlorite can lead to a micro-pitting phenomenon. Additionally, oxygen in the autoclave can result in the formation of nitric oxide, which further contributes to roughness on the instruments. This roughness may reduce the cutting ability of NiTi instruments over time.

Conclusion:

Based on various studies, the autoclave process is considered the most effective method for sterilizing endodontic instruments. Glutaraldehyde sterilization is more effective at eliminating pathogens from the treated surface compared to glass bead sterilization. Presterilization is helpful in removing up to 40% of debris and pathogens from the surface. Additionally, an ultrasonic bath is more effective than handwashing for cleaning instruments.

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