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Cavity Disinfection In Operative Dentistry – Review

Operatif Diş Hekimliğinde Kavite Dezenfeksiyonu – Derleme

ABSTRACT

Objective: Elimination of residual microorganisms and their effects before placement of restorative materials after cavity preparation increase the longevity of the restoration and the success of the treatment. Complete destruction of bacteria during cavity preparation can mechanically weaken the tooth structure as well as affect the vitality of the pulp. Therefore, disinfection of the cavity after caries removal can help prevent secondary caries and postoperative sensitivity by eliminating residual bacteria. However, different types of cavity disinfectants are introduced the usage of dental clinicians and the effects of disinfectants these disinfectants on restorative materials are being investigated in literature.

Conclusion: This review aims to provide information about the effects of cavity disinfectants used in restorative dentistry through a review of the current literature review and to assist dentists in making clinical decisions about using cavity disinfectants during restorative procedures.

Key Words: Bacteria, Dentistry, Cavity Disinfection.

ÖZ

Giriş: Kavite preparasyonu sonrası restoratif materyaller yerleştirilmeden önce rezidüel mikroorganizmaların eliminasyonu ve etkilerinin ortadan kaldırılması; restorasyonun ömrünü ve tedavinin başarısını artırmaktadır. Kavite preparasyonu sırasında bakterilerin tamamen yok edilmesi mekanik olarak diş yapısını zayıflatmanın yanı sıra pulpanın canlılığını da etkileyebilir. Bu nedenle, çürük uzaklaştırıldıktan sonra kavitenin dezenfeksiyonu; rezidüel bakterilerin eliminasyonu ile ikincil çürüklerin ve operasyon sonrası duyarlılığın önlenmesine yardımcı olabilir. Bununla birlikte, farklı kavite dezenfektanları diş klinisyenlerinin kullanımına sunulmakta ve bu dezenfektanların restoratif materyaller üzerindeki etkileri literatürde araştırılmaktadır.

Sonuç: Bu derleme; mevcut literatür incelemesi sonucu restoratif diş hekimliğinde kullanılan kavite dezenfektanlarının etkileri hakkında bilgi sağlamayı ve diş hekimlerine restoratif prosedürler sırasında kavite dezenfektanlarını kullanma konusunda klinik karar vermede yardımcı olmayı amaçlamaktadır.

Anahtar Kelimeler: Bakteri, Diş Hekimliği, Kavite Dezenfeksiyonu.

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INTRODUCTION

The purpose of a successful restorative treatment is to provide a sealed restoration of the cavity after the caries has been removed and to regain the mastication function. Today, traditional cavity preparation principles that suggest the complete removal of the caries have been replaced by conservative approaches that suggest only the removal of soft and denatured dentine. After the caries has been removed; visual caries detection, based on the color and hardness of the dentine, is not suitable for objective evaluation, since it is insufficient to provide information about the bacterial status of the cavity (1). Residual bacteria in dentine may increase by maintaining its enzymatic activities (2). Therefore, it is recommended to disinfect the cavities in order to prevent postoperative sensitivity, secondary caries and pulpal inflammation caused by residual bacteria (3).

Chemicals such as phenol, thymol and silver nitrate, which were suggested in the past as cavity disinfectants that inhibit residual bacteria in dentin, are no longer used because they cause irritation in the pulp tissue(4).

According to the results of studies on materials used in cavity disinfection, the features expected from an ideal cavity disinfectant are as follows (5):

- Should have a bactericidal effect when used in low concentrations,
- Should not damage soft tissues and pulp during application,
- Should be broad spectrum,
- Must have long-term effect even in the presence of saliva,
- Should not cause discoloration in tooth tissues.

Today, chlorhexidine digluconate, benzalkonium chloride, sodium hypochlorite, hydrogen peroxide, iodine solutions, phosphoric acid, fluoride, propolis, ozone, light-activated disinfection systems and laser are used as cavity disinfectants (6).

Chlorhexidine

In dentistry, chlorhexidine digluconate is used in the chemical control of microbial dental plaque and in the prevention of dental caries (7). Chlorhexidine, one of the bis-biguanide compounds, is effective on gram (+) and gram (-) facultative anaerobic and aerobic microorganisms with its broad-spectrum antibacterial properties (8). It is known that chlorhexidine is particularly effective on *S. mutans* and *S. sangius* (9).

Chlorhexidine affects the metabolic activities of bacteria and while it is bacteriostatic at low concentration; it acts as a bactericide at high concentration (10). At low concentrations, positively charged chlorhexidine molecules bind to the phosphate groups of gram (+) bacteria and to the lipopolysaccharides on the surface of gram (-) bacteria, thereby disrupting the integrity of the bacterial cell membrane and increasing its permeability. Thus, the cellular functions of bacteria are disrupted and their proliferation is prevented (11). In high concentrations, chlorhexidine enters the bacterial cell, causing agglutination of the cytoplasm by cross protein binding. It causes irreversible cell damage by inhibiting glycosyltransferase enzyme (12). The efficacy of chlorhexidine is highest in the pH between of 5.5 and 7 (13).

Chlorhexidine is cationic due to its positive charge and has affinity for negatively charged surfaces (bacterial cell wall, extracellular polysaccharides, hydroxyapatite, pellicle, salivary mucins and oral mucosa). With this feature, it reduces pellicle formation and can maintain its existence in the environment for a long time by controlled release from the surface (14).

The reason for using chlorhexidine as a cavity disinfectant is to benefit from its antibacterial effect. It is known to be successful in the elimination of residual microorganisms in the cavity after the caries is removed (15). Chlorhexidine is a matrix metalloproteinase (MMP) inhibitor, in addition to its antimicrobial properties. MMPs in dentin and dentinal fluid contribute to the enzymatic degradation of the adhesive hybrid layer and thus to the reduction of bond durability over time (16). MMPs cause destruction of the hybrid layer, which is important in adhesion. Chlorhexidine is effective in maintaining the dentin-resin bond strength as an MMP inhibitor. It does this by removing debris from the smear layer, increasing the penetration of acidic monomers in adhesive systems, and increasing the surface energy and wettability of dentin(3,17). Chlorhex (0.2% chlorhexidine gluconate) and Cervitec (0.2% chlorhexidine digluconate) are are the materials that can be an example of mouthwashes application form. Cervitec Plus (1% chlorhexidine diacetet) and Corsodyl (1% chlorhexidine digluconate) are the materials that can be an example of gels application form. Cavity Cleanser (2% chlorhexidine digluconate) and Consepsis Scrub (2%

chlorhexidine gluconate) are the materials that can be an example of cavity cavity disinfectants application form (18).
It has been reported that 2% chlorhexidine application applied for 60 seconds in deep carious lesions during restorative treatment increases the success of indirect pulp capping by helping dentin bridge formation (19).
Chlorhexidine is known to cause staining on the teeth, especially with long-term use of mouthwashes. Although chlorhexidine allergy is rare, high concentrations can cause contact dermatitis, desquamative gingivitis, and taste changes (18).
In a systematic review, it was concluded that chlorhexidine, with proven in vitro and clinical applicability, is a safe option for cavity disinfection before adhesive procedures, as it adequately protects dentin adhesion (20).

Benzalkonium Chloride

Benzalkonium chloride is one of the quaternary ammonium compounds with antiseptic effect. It is a cationic surfactant such as chlorhexidine. It acts by binding to the phosphate groups of teichoic acids in the cell wall of Gram (+) bacteria, and to phosphate groups and membrane lipopolysaccharides in the cell wall of Gram (-) bacteria (21). Since the cell wall of microorganisms (especially gram(-) bacteria) has a lipoprotein structure, benzalkonium chloride, which is one of the surface active detergents, affects this structure, impairing the permeability of the cytoplasmic membrane and exerts a bactericidal effect (22).
Studies have shown that benzalkonium chloride has antibacterial activity on microorganisms such as *Streptococcus mutans, Streptococcus salivarius, Actinomyces viscosus, L. acidophilus and Staphylococcus aureus,* and it was thought that its use would be appropriate for the elimination of residual microorganisms in the cavity before restorative procedures (23, 24).
Chan and Lo, in their study examining the antibacterial effect of adding 1% and 2% benzalkonium chloride to phosphoric acid on *S. sobrinus*, reported that antibacterial effect was achieved in all groups where acid agent containing benzalkonium chloride was applied. It is known that benzalkonium chloride, whose effectiveness decreases in the presence of organic compounds such as blood, serum and saliva, and in acidic environments, is more effective in basic media (25).
An antibacterial agent containing benzalkonium, a preparation called Tubulicid Blue / Red (Suredental, Canada) on the market, is used as a cavity disinfectant in studies (26). This agent removes the smear layer without opening the dentinal tubules. In addition to benzalkonium chloride, there is 1% sodium fluoride in the red colored agent (Tubulicid Red). It is used in cavity disinfection and dentin sensitivity treatment. Blue colored agent (Tubulicid Blue) is used for cleaning colored surfaces before crown and bridge cementation. Hypersensitivity reactions have been reported rarely in the use of benzalkonium chloride other than for cavity disinfection (27).

Sodium hypochlorite

Sodium hypochlorite is a broad spectrum antimicrobial agent known to be effective against bacteria, bacteriophages, spores, fungi and viruses (28). Sodium hypochlorite shows its antimicrobial effect by oxidizing and hydrolyzing cell proteins. When sodium hypochlorite comes into contact with tissue proteins, the peptide bonds of tissue proteins are broken and the proteins are dissolved. In addition, the hydrogen in the amino groups reacts with chlorine to form chloramine, which plays a role in antimicrobial activity. In low concentrations, sodium hypochlorite causes an inflammatory reaction when it comes into contact with vital tissues, while at high concentrations it can cause tissue damage (29). In addition to its antiseptic effect, sodium hypochlorite causes endothelial damage, toxic reactions against fibroblasts and lymphocytes, and cellular degenerations at high concentrations of 5.25% (30).
Sodium hypochlorite's concentration of 1-5.25% is used as an irrigation solution in endodontic treatments due to its bactericidal and organic tissue dissolving properties (31). A concentration of 5.25% has been shown to be effective on *E. faecalis* and *S. mutans* (32, 28). Although sodium hypochlorite is not effective in completely removing the smear layer in the intertubular area, it has been shown that it can remove smear plugs in the canal orifices (33).
The use of sodium hypochlorite in cavity disinfection is controversial as it removes collagen from dentin and prevents hybridization created by adhesive systems (29). At the same time, sodium hypochlorite breaks down to form sodium chloride and oxygen. Oxygen inhibits the polymerization of resin based materials (34). Therefore, sodium hypochlorite is not preferred as a cavity disinfectant in restorative applications (35).

Hydrogen Peroxide

Hydrogen peroxide is a colorless, odorless liquid that dissolves in water. It is a substance that has an antiseptic effect with the oxygen released by decomposing into water and oxygen upon contact

with tissues with necrotic cells (36). Hydrogen peroxide is effective on bacteria, fungi, viruses and spore-forming microorganisms. The antibacterial effect of hydrogen peroxide is based on its oxidation property. Bacteria without catalase activity are sensitive to hydrogen peroxide because they cannot degrade peroxide (37). Although microorganisms with catalase activity, such as staphylococci, can be protected from oxidation, it has been shown that they are affected by high concentrations of hydrogen peroxide (38). In a study evaluating the antibacterial activities of phosphoric acid applications with and without benzalkonium chloride against *S. mutans* without catalase activity, it was found that phosphoric acid containing 3% hydrogen peroxide showed the most antibacterial effect (28). In addition to its antibacterial effect, the foaming effect of hydrogen peroxide helps the cavity walls to be cleaned better. For this purpose, it is recommended to clean the cavity walls with a cotton pellet impregnated with 2-3% hydrogen peroxide before placing the restorative material in the cavity (23).

Hydrogen peroxide releases oxygen, inhibits the polymerization of resin-based materials and has a disadvantage in terms of adhesion (34). In a study evaluating the effect of hydrogen peroxide on microleakage of composite resin restorations, it was observed that hydrogen peroxide significantly increased microleakage. Therefore, the use of hydrogen peroxide as a cavity disinfectant in clinical practice is controversial (39). In addition, studies on free radicals have shown that it is necessary to approach carefully in the use of oxygen-releasing solutions on living tissues (36).

Antibacterial Dentin Bonding Systems

The minimal cavity preparation approach in restorative dentistry has made the use of composites and adhesive agents widespread (40). In self-etching adhesive systems, smear layer containing bacteria and demineralized dentin cannot be removed from the cavity since there is no etching procedure with acid and rinse. Therefore, it may be necessary to disinfect the cavity before the application of these systems. The use of cavity disinfectants may adversely affect the bond strength of composite resins. For this reason, antibacterial effective bonding systems have been produced and it is aimed to eliminate the bacteria remaining in the cavity (41).

It was thought that MDPB, an antibacterial monomer, could be added to the self-etching primer to prevent secondary caries (42). MDPB is a monomer that has the effect of inhibiting the entry of bacteria from the dentin-resin interface, which ensures the elimination of residual bacteria in the cavity. The MDPB antibacterial monomer remains stable, except that it does not prevent the colonization of the bacteria, and when it comes into contact with the bacterial surface, it causes the bacterial cell to die or become inactive. In this way, it acts before and after polymerization (43). In a study evaluating the antibacterial activities of dentin bonding systems, it was reported that 5% glutaraldehyde had a very high antibacterial effect on dentin (44). Glutaraldehyde can be used as a pre-bonding agent for desensitization and because of its antibacterial effects (45).

Iodine Solutions

The antiseptic properties of iodine have enabled it to be used in medicine and dentistry. It has bactericidal effects on gram (+) and gram (-) microorganisms. They show low activity against fungi and viruses. Sporoside effects are negligible (37). Its effectiveness varies according to pH, temperature, application time and concentration. It creates an antibacterial effect by affecting the cell wall and disrupting the electron transport of bacteria through oxidative way (46). The iodine solution containing copper sulfate, commercially named ORA-5 (Canker Sore Medicine) for antibacterial purposes, is applied in the treatment of aphthous ulcers in the mouth (47).

Phosphoric acid

The smear layer formed as a result of the dentin preparation covers the canal orifices and reduces the permeability, adversely affects the adhesion of the adhesive restorative materials to the dentin and creates a suitable environment for the microorganisms to maintain their viability. For this reason, there is a view to remove the smear layer before applying the bonding system. Phosphoric acid is used in dentistry to disinfect the cavity and remove the smear layer. The antibacterial effects of the acids used vary depending on the concentration, type and application time of the acid (48). When the literature is reviewed, studies are continuing on the minimum time and acid concentration to achieve appropriate etching without damaging the pulp tissue (49, 50).

Fluoride

In caries prophylaxis, fluoride in saliva and plaque prevents demineralization of enamel, while uptake of fluoride together with phosphate and calcium into the structure of demineralized enamel provides remineralization (51). At the same time, fluoride inhibits bacterial metabolism and reduces acid production, changes the cell wall structure, disrupts

the potassium-phosphorus balance, and ensures bacterial elimination (52). The remineralizing properties and bactericidal effects of fluoride suggest that it can be used as a cavity disinfectant (53). When the literature is examined, there are not enough studies on this subject.

Propolis

Today, the increasing use of natural products has led to the research of these products in the field of health (54). Propolis, which is also researched in the field of dentistry; it has antimicrobial, antiviral, anti-inflammatory, regenerative, immunomodulatory, antioxidant, antimutagenic and carcinostatic properties (55). These properties suggest its use as a cavity disinfection.

Propolis shows strong antimicrobial activity on cariogenic microorganisms such as *S. mutans, S. sobrinus* and *Candida albicans* (56). When the literature is examined, there are not enough studies on this subject.

Ozone

Ozone, which has a very high oxidation power, is the strongest disinfectant known. With its strong antibacterial, antiviral and antifungal effects, the usage areas of ozone therapy are increasing. It is an important advantage that ozone does not leave residue after disinfection (57).

Ozone is an alternative non-invasive antibacterial agent that is used to reduce the number of cariogenic bacteria in dental plaque and to prevent caries formation (57). It provides disinfection by inhibiting the growth of pathogenic microorganisms, neutralizing them or destroying the cell Wall (58). It also blocks the enzymatic control systems of cells by acting on glycoproteins, glycolipids and other amino acids. As a result, membrane permeability increases, causing the death of microorganisms (57). At the same time, it reduces the demineralization of enamel by increasing the resistance of the tooth to microbial activity (59).

A 99% decrease was observed in the numbers *of S. mutans, S. sobrinus* and *Lactobacilli,* which are effective in the formation of dental caries, with the application of ozone for 10 - 20 seconds. HealOzone (Kavo, Germany) and OzonyTron (Mymed, Germany) are used in ozone treatment (56). In these devices, ozone molecules with the high kinetic energy of the particles disperse into the lesion, creating a rapid oxidative reaction and gas reaction. The destruction of the bacterial cell wall takes place. As a result of lactic acid neutralization, demineralization and caries progression are stopped (59).

Lasers

It is thought that residual bacteria in the smear layer will continue their enzymatic activities and cause restoration failure (60). It is thought that lasers will play an important role in cavity disinfection by eliminating the smear layer and eliminating residual bacteria (61). High-power lasers show their effectiveness by producing photochemical changes due to free radical formation in target cells, photothermal due to heat generation, photoablative changes due to destruction of chemical bonds, or photomechanical changes due to shock waves emitted from the plasma (62). The antibacterial effectiveness of lasers varies depending on many factors, such as laser energy, water content and volume of the cell, strength of the cell wall, absorption properties, and movement of bacteria in the dentinal canals (63).

The diode laser, which is among the soft tissue lasers, causes coagulation and vaporization in the tissue. In dentistry, diode laser is used in teeth whitening, soft tissue surgery, removal of melanin pigmentation and low-level laser therapy (64). Due to its antimicrobial activity, it is also used in endodontic treatments and cavity disinfection (63). In a study, it was reported that diode laser irradiation (445 nm) could eliminate bacteria in the deep dentin layer. In this study, it was stated that the photonic bactericidal activity was dependent on the dose of the laser, the thickness of the dentin layer and its moisture (65).

Photoactivated disinfection

Photoactivated disinfection is based on the principle of activating target cells or microorganisms with light of a specific wavelength by staining them with a non-toxic photosensitive substance (66).

In photoactivated disinfection, the molecules in the photosensitive substances are attached to the bacterial wall, and light at a wavelength that these molecules can absorb is applied. With the energy absorbed from the light, oxygen is transformed into reactive oxygen residues such as oxygen ions and radicals. Reactive oxygen residues rapidly and strongly break down the bacterial membrane and DNA, causing cell death (67). Its effectiveness is not limited to bacteria, but it is also effective on many microorganisms such as viruses, protozoa and fungi. It is thought that the light-activated disinfection system may be an alternative treatment option against microorganisms that are resistant to antimicrobial agents (68).

Although the use of phenothiazine-based dyes such as toluidine blue, methylene blue and malachite green in photoactivated disinfection has positive effects, photosensitizers may cause tooth discoloration (69).
Photodynamic therapy is used in medicine, especially cancer treatments. It is used in dentistry for the treatment of oral cancers, bacterial / fungal infections in the mouth, endodontic treatments and cavity disinfection (70).
While neutral or anionic photosensitive agents can bind effectively to gram (+) bacteria, they cannot bind effectively to gram (-) bacteria. A cationic molecule must be added to these agents in order to ensure effectiveness in gram (-) bacteria (70). A source that produces visible light with a special wavelength, low power and in light-activated disinfection systems is required. The light sources used for this purpose are argon, KTP and Nd:YAG lasers. Today, most of the light-activated disinfection systems use red lights with a wavelength of 630-700 nm, which provides long wavelength and deep light penetration (71).

CONCLUSION

Agents used in cavity disinfection are recommended because of their antibacterial activity. However, the use of cavity disinfectants for this purpose has some disadvantages. In particular, it is known that some disinfectants cause microleakage by affecting the bonding of restorative materials to dental tissues. In the current literature, it is thought that the closest to ideal cavity disinfectant is chlorhexidine, which is applied at a concentration of %2 (19). Laser, light-activated systems and ozone devices show promising results in terms of adhesion and biocompatibility of modern disinfection methods. However, these methods should be used carefully to avoid possible side effects. There is not yet sufficient evidence for the use of natural disinfectants such as propolis. More studies are needed to evaluate the effects of cavity disinfectants used to prevent secondary caries and post-operative sensitivity. The results obtained by comparing different cavity disinfectants can contribute to clinical applications.

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