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Evaluation of the Effects and Effectiveness of Cavity Disinfectants

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Abstract

Complete elimination of bacteria from a carious tooth during cavity preparation is considered as a difficult task in terms of clinical evaluation. In addition to weakening the tooth structure, attempts to completely remove largescale carious tissue with only mechanical procedures can affect the viability of the pulp. Therefore, disinfecting the cavity after preparation can help eliminate bacterial residue that may be responsible for recurrent caries, postoperative sensitivity, and restoration failure. However, the effects of cavity disinfectants on restorative treatment have been a major concern for dentists and researchers. This review aims to explore the available literature and provide information on the different materials and techniques used for cavity disinfection and to demonstrate their effectiveness in operative dentistry, and consequently to assist dentists in making clinical decisions about using cavity disinfectant during restorative procedures.

1. Introduction

In a successful restorative treatment, it is aimed to restore the cavity with restorative materials in a leakproof manner and to give the patient a comfortable chewing function. While removing the caries, it is aimed to protect the healthy and remineralized tissue and to remove the demineralized, soft and infected tissue that cannot be remineralized. It is known that the elimination of bacteria that may remain in the cavity walls, enamel-dentin junction, smear layer and dentinal tubules before restoration is of great importance. Because these bacteria can cause the

seconder caries. To eliminate this situation, the use of antimicrobial effective restorative materials, dentin bonding systems, acids and cavity disinfectants has become the main topic of the conversation (Brannström and Nyborg, 1973; Meiers and Kresin, 1996; Türkün, Türkün, Ateş, 2003).

2. Cavity Disinfectants

2.1. Chlorhexidine gluconate

Chlorhexidine (CHX) was developed in the UK in the 1950s and was accepted in the USA in the 1970s. It was used as an antiseptic for skin wounds in 1954 (Uygun, 2007). It was started to be used in dentistry as a mouth disinfectant before surgery and as a canal irrigation agent in endodontics. Nowadays, its usage area is increasing. Chlorhexidine is available in three forms as digluconate, acetate and hydrochloride salt (Fardal and Turnbull, 1986; Colonay, 2005).

Chlorhexidine is effective against gram-positive and gram-negative bacteria and fungi, as well as cathepsin MMP 2, 8 and 9 (Scaffa et al., 2012). At low concentrations, CHX has a bacteriostatic effect, promoting the release of low molecular weight molecules (potassium and phosphorus) by changing the osmotic balance of the bacterial cell. On the other hand, it has a bactericidal effect at high concentrations, causing an increase in membrane permeability, causing cell cytolysis. Consequently, the release of large intracellular components, including potassium, changes the cell structure, causing the precipitation of cytoplasmic proteins (Di Hipólito et al., 2012).

Tazegül et al. (2006) found that solutions containing chlorhexidine gluconate caused a decrease in the amount of plaque S. mutans and this situation continued in 3-month controls. Regarding the duration of the CHX application, there was no significant difference between the application times (Öznurhan and Buldur, 2015).

Reported effects of different concentrations of CHX on restorative treatment vary depending on the type of adhesive system used, the form, concentration of CHX, and the aging process (Bin-Shuwaish, 2016).

There are studies reporting that higher bonding strength occurs when etch and rinse adhesive systems are used instead of self-etch adhesive systems after the application of resin composite to dentine CHX (Celik, Ozel, Bagis, Erkut , 2010; De Campos, Correr, Leonardi, Pizzatto, Morais, 2009; Zheng, Zaruba, Attin, Wiegand, 2015; Reddy et al., 2013; Ercan et al., 2009; Di Hipólito et al., 2012). It is thought that the negative effect of 2% CHX application on bond strength in self-etch adhesive systems and cements is caused by the functional monomer named 10-methacryloyloxydecyl dihydrogenphosphate (MDP), which is affected by CHX in self-etch adhesive systems (Shafiei and Memarpour, 2012).

In permanent teeth, it has been reported that CHX solutions do not significantly affect microleakage of restorations bonded with etch-and-rinse adhesive systems (Breschi et al., 2009; Loguercio et al., 2016).

In a study evaluating the effect of two etch-and-bond adhesive systems (Prime & Bond NT and Adper Single Bond 2) on nanoleakage when cavity disinfected with 2% CHX, an increase in nanoleakage was reported in the non-disinfected groups after 24 months of aging (Loguercio et al., 2016). However, Memarpour, Shafiei, and Moradian (2014) reported different results, as they found that 2% CHX disinfection increased the micro-leakage of composite restorations after acid etching and before Adper Single Bond 2 application in deciduous teeth.

Another factor affecting the bonding is the residual moisture of 2% CHX solution, which contaminates the bonded surface and changes the ability of the

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hydrophilic resin in the self-etch system to cover the dentine (Hiraishi, Yiu, King, Tay, 2009; Singla, Aggarwal, Kumar, 2011). This may also explain why the bonding at the tooth-resin interface has not changed which is caused by 1% CHX gel application prior to the use of self-etch adhesive systems reported in several studies (Singla, Aggarwal, Kumar, 2011; Ercan et al., 2009; Sharma, Rampal, Kumar, 2011). The gel form of the disinfectant cannot wet the dentin surface and cannot penetrate the dentinal tubules as the solution forms.

Matrix metalloproteinases in dentin have been shown to play a role in the degradation of unprotected collagen fibrils within the hybrid layer (Almahdy et al., 2012). It is thought that CHX's ability to inhibit matrix metalloproteinases (MMPs) found in acidified dentin increases the bonding strength and therefore, MMP inhibitors such as CHX may prolong the bonding life of the adhesive to dentin (Mazzoni et al., 2015).

Cha and Shin (2016) recommend washing the cavity walls before applying the self-etch adhesive and after using 2% CHX to achieve better composite adhesion when using self-etch adhesive systems.

In amalgam restorations and before amalgam placement, 2% CHX application has been shown to reduce microleakage and postoperative sensitivity (Al-Omari, Al-Omari, Omar, 2006; Piva, Martos, Demarco, 2001).

2.2. Benzalconium chloride

Benzalconium chloride (BAC); It is a disinfectant from quaternary ammonium compounds with antiseptic effect and is used in concentrations of 0.4-1.6%. BAC removes the smear layer without opening the dentinal tubules and acts by cationic binding to the bacterial cell wall in gram (+) bacteria, and by cationic binding to the phosphate groups and membrane lipopolysaccharides in the cell walls in gram (-) bacteria (Chan and Lo, 1994; Erganiş and Öztürk, 2003, p.:82). Benzalkonium chloride, whose effectiveness is reduced in the presence of organic compounds such as blood, serum and saliva and in an acidic environment, has been found to be more effective in a basic environment like all other quaternary ammonium compounds (Chan and Lo 1994). Although it shows strong antimicrobial properties, its antimicrobial activity was found to be lower than CHX (Turkun, Ozata, Uzer and Ateş, 2005).

As with CHX, it has been documented that BAC is an effective MMP inhibitor capable of preserving the adhesion of the resin restoration to dentin (Mazzoni et al., 2015).

Sharma et al. (2009) stated that 2% CHX and 1% BAC can be used safely in terms of microleakage. Say et al. (2004) reported that 2% CHX and 1% BAC solutions did not have a significant effect on microtensile and micro shear bond strength. However, recent studies show that benzalconium chloride reduces binding in self-etch and total-etch systems (Karuna, Arathi, Nayak,'2018).

2.3. Sodium hypochlorite

Sodium hypochlorite (NaOCl) is a greenish colored liquid formed by the reaction of diluted caustic soda with chlorine in liquid or gaseous form. NaOCl has proven effective against bacteria, spores,

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bacteriophages, fungi and viruses as a broad spectrum antimicrobial agent (Pashley, 1985).

Regarding the effect of NaOCl on bond strength, there is a controversy similar to that of CHX. Several studies have reported that NaOCl negatively affects attachment strength (Reddy et al., 2013; Elkassas et al., 2014). Among the reasons for this situation, there are differences between methodology, dentin substrate and bonding material production (Reddy et al., 2013). Even the application time of NaOC1 has an effect on the bond strength. It has been stated that 30 seconds pre-treatment with NaOC1 had a detrimental effect on bond strength, while the same pre-treatment for 15 seconds had no significant effect (Pattanaik and Chandak, 2013; Arslan et al., 2011).

Studies showing that the bond strength increases when NaOCl is used with self-etch adhesive systems, stated that this may be due to the non-specific proteolytic property of NaOCl (Reddy et al., 2013; Ercan et al., 2009; Fawzy, Amer, El-Askary, 2008). The application of NaOCl on the smear layer removes the collagen phase and enriches the dentin surface in terms of hydroxyapatite crystals and ultimately increases the chemical bonding of self-etch adhesive systems (Elkassas, Fawzi, El Zohairy, 2014).

NaOCl is decomposed into sodium chloride and oxygen. It is known that the resulting oxygen, when used for cavity disinfection, disrupts the polymerization of resin-based materials. In addition, it was stated that NaOCl removes collagen in dentin and prevents hybridization obtained with adhesive systems (Perdigao, Lopes, Geraldeli, Lopes, Garcia Godoy, 2000).

2.4. Iodine solutions

It has been proven that 2% iodine solution has a bactericidal effect, so it is effectively used for cavity disinfection in restorative dentistry (da Silva, Calamia, Coelho, Carrilho, de Carvalho, Caufield, 2006).

It has bactericidal effects on gram (+) and gram (-) microorganisms. They show low activity against fungi and viruses. Sporoside effects are almost nonexistent (McDonnell and Russell, 1999; Colonel, 2005; Uygun, 2007). Iodine shows its effect by penetrating the cell wall and disrupting the electron transport of bacteria by oxidative way (Colonel, 2005). Its effectiveness is fast and powerful. Its effect varies with pH, temperature, application time and concentration (Uygun, 2007).

When 2% iodine solution was applied before adhesive application, it resulted in low microtensile bond strength values for ethanol or water-based adhesives. The low bond strength values for ethanol and/or water-based adhesives are thought to be due to incomplete removal of glycerol (53%) used as carrier. Residual glycerol can inhibit hybrid layer formation and eventually cause phase separation between the water/ethanol-based adhesive and glycerol as the solvents evaporate, affecting adhesion. But in the case of an acetone-based adhesive, acetone can now penetrate glycerol and therefore has no effect on the bond strength (Karuna et al.'2018).

2.5. Ozone

In nature, ultraviolet (UV) rays from the sun break down the oxygen in the atmosphere and convert it into ozone molecules. Technologically, it is obtained from the air we breathe or pure oxygen with the help of

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electron discharge. This gas, which has a very high oxidation effect, is the strongest known disinfectant. Since it is a natural disinfectant, its usage areas have become widespread rapidly and used safely (Azarpazhooh and Limeback, 2008; Atabek and Öztaş, 2011). In addition, ozone, due to its unstable structure, always turns into oxygen, which is its raw material, after it completes its disinfection task, so the fact that ozone gas is the only disinfectant that does not leave any residue and residue after disinfection makes it more advantageous compared to other disinfectants (Azarpazhooh and Limeback, 2008).

The effect of O3 on the bond strength of dental composites has been evaluated in many studies and it has been stated that it has no effect on bond strength and microleakage (Shafiei and Memarpour, 2012; Duki, Duki and Milardovi, 2009; Marchesi et al., 2012). But variable results are also seen depending on the form of used ozone (water or gas). When micro tensile bond strength (µTBS) is evaluated after cavity disinfection before acidification, liquid ozone; the gas showed higher values than ozone and CHX; It is stated that liquid ozone can open the dentinal tubules by removing organic debris (Karuna et al., 2018). It has been found that ozone gas does not compromise the bonding strength or microleakage scores regardless of the adhesive system used and that the adhesive cements do not affect the bonding strength of the resin-dentin/enamel of etch-and-rinse and self-etch adhesive systems (Çehreli, Yalçınkaya, Guven-Polat, Çehreli, 2010; Schmidlin, Zimmermann and Bindl, 2005; Kapdan and Öztaş, 2015; Arslan et al., 2011; Cadenaro et al., 2009).

2.6. Lasers

An alternative to chemicals for cavity disinfection is lasers (Öznurhan and Buldur, 2015a). Lasers are devices that emit different wavelengths (Bin-Shuwaish, 2016). Lasers such as KTP (potassium-titanyl-phosphate), CO2 (carbon dioxide), Nd: YAG (neodymium), Er: YAG (erbium) and Er, Cr: YSGG (erbium, cromium) are suitable for cavity disinfection as they remove debris and smear layer effectively (Öznurhan, Öztürk, Ekci, 2015b Arslan et al., 2011; Kapdan, Öztaş, Sümer, 2013).

The use of laser causes the intubular water of the bacterial cell to expand and has thermal and photodisruptive effects on bacteria, leading to cell growth impairment and lysis (Mohan, Uloopi, Vinay, Rao, 2016). De Sousa Farias, Nemezio, Corona, Aires, Borsato (2016) reported that low-level laser antimicrobial photodynamic therapy (aPDT) significantly reduced the number of viable bacteria in the S. mutans biofilm. In an in vivo study, Mohan et al. (2016) compared the antimicrobial activities of different disinfectants (including diode laser). The amount of S. mutans and Lactobacilli was lower in the diode laser group compared to the control group; however, it was reported that this antimicrobial activity was not significantly different from that obtained with 2% CHX. The effectiveness of the Er: YAG laser as an antimicrobial agent and as a smear layer remover has also been documented (Takeda, Harashima, Kimura, Matsumoto, 1999).

Çelik, Özel, Bağış, and Erkut (2010) reported that laser beam, as a cavity disinfection procedure, can increase the bond strength in total-etch and self-etch adhesive systems, but may vary depending on the adhesive system used. Arslan et al. (2012) reported

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that laser and other cavity disinfectants do not make a difference in terms of microleakage in total-etch systems, but in self-etch systems this is due to the cavity disinfectant used.

2.7. Aloe vera (Aloe Barbadensis Miller)

Another emerging cavity disinfectant is Aloe vera gel. It is a promising material for use in dentistry due to its potential antimicrobial, antioxidant and anti-inflammatory properties with low cytotoxicity levels (Tüzüner et al., 2013).

The ethanolic extract of aloe vera has been found to destroy almost all of the bacteria after cavity disinfection (Prabhakar, Karuna, Yavagal, Deepak, 2015). However, in a study examining the antimicrobial effectiveness of aloe vera and propolis, ethanolic extracts of aloe vera and propolis were only bacteriostatic and their antimicrobial activity, streptococcus mutans and lactobacillus acidophilusIt was concluded that it is lower than chlorhexidine (Mahabala, Shrikrishna, Natarajan, Nayak, 2016). However in a study evaluating the effect of different cavity disinfectants on bond strength in total-etch adhesive systems, it was reported that aloe vera and CHX increased the bond strength (Sinha et al., 2018).

2.8. Propolis

Propolis is a natural resin produced by honey bees and known for its antimicrobial, antifungal, healing, anti-inflammatory, anesthetic activities (Öznurhan and Buldur, 2015a; Kandaswamy, Venkateshbabu, Gogulnath, Kindo, 2010). It is pointed out that it is sensitive to propolis and therefore can be used in the treatment of tooth decay (Öznurhan, Öztürk, Ekci, 2015b). Mohan et al. (2016) and Eralp et al. (2016) reported that propolis is as effective as 2% chlorhexidine in cavity disinfection.

When the effect on µTBS after cavity disinfection with propolis was evaluated, the observed micro-tension bond strength was found to be lower than the laser group but higher than the ozone group (Öznurhan and Buldur, 2015a). When microleakage scores were evaluated after applying propolis to cavities, higher scores were observed with self-etch adhesive, while no difference was observed with etch and rinse adhesive (Cadenaro, Delise, Antoniollo, Navarra, Di Lenarda, Breschi, 2009). It has been reported that these increased microleakage scores can be attributed to the mild aggressive effects of propolis on dentin (Öznurhan, Öztürk, Ekci, 2015b).

2.9. Salvadora persica

Salvadora persica (toothbrush tree) is a member of the Salvadoraceae family and has been used as a natural toothbrush (miswak) for many years (Halawany, 2012).

Many studies report that S. persica extracts have antimicrobial effects against cariogenic pathogens (Sofrata, Claesson, Lingström, Gustafsson, 2008; El-Latif Hesham, Alrumman, 2016). Additionally, several surveys have reported lower caries levels among miswak users compared to non-users (Sathananthan, Vos, Bango, 1996). In addition, S. persica extracts have been reported to remove the smear layer after application to dentine (Balto, Ghandourah, Al-Sulaiman, 2012).

Salama, Balto, Al-Yahya and Al-Mofareh (2015), the use of 1 mg/mL ethanol extract of S. persica with 0.2% CHX and 1.3% NaOCl in dentin disinfection, stated

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that resin restorations have no significant effect on microleakage.

2.10. Morinda citrifolia

Morinda citrifolia (noni) is a tropical tree known to have a wide variety of therapeutic effects and nutritional values and is therefore frequently used in traditional medicine (Wang et al., 2002).

The antimicrobial effects of M. citrifolia juice (MCJ) against oral pathogens are well documented (Kandaswamy et al., 2010; Podar, Kulkarni, Dadu, Singh, Singh, 2015; Murray, Farber, Namerow, Kuttler, GarciaGodoy, 2008). Kandaswamy et al. (2010) reported that the antimicrobial activity of MCJ is equal to that of propolis, but lower than a 2% CHX solution. Dikmen et al. (2015) concluded that the addition of MCJ to NaOCl for cavity disinfection significantly increases bond strength. In addition, the effectiveness of 6% MCJ as a smear layer remover has also been proven in the literature (Podar et al., 2015; Murray et al., 2008).

3. Conclusion

Within the limitations of this literature review, the following conclusions can be drawn:

1. The antimicrobial effectiveness of the different disinfectants is well documented; however, the antimicrobial effectiveness of some agents may vary depending on the percentage and/or duration of application.

2. The choice of cavity disinfectant is dependent on the type of adhesive system.

3. Although it is believed that the effect of cavity disinfectant application on the tooth/restoration connection interface is material-based; The literature strongly supports the use of 2% CHX solutions when using etch and rinse adhesive systems.

4. There is evidence that the use of 1% CHX gel as cavity disinfectant is more appropriate in self-etch adhesive systems. However, more research is needed to evaluate its biocompatibility with different systems.

5. Modern disinfection systems such as laser and O3 devices show promising results in terms of biocompatibility with adhesive systems and restorative materials. However, these devices should be used with caution to avoid any side effects.

6. There is insufficient clinical and laboratory evidence for the use of natural-based disinfectants; Adequate information on side effects and adverse events is not available. Therefore, more studies are needed to evaluate these products.

Conflict of interest

The authors declare no conflicts of financial, economic or professional interests about ‘The Effectiveness of Cavity Disinfectants’ study.

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