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Original Article

The Effect of Different Cavity Disinfectants on the Bonding Strenth of Non-Light Curing Adhesive Agent

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When all the bacteria in cavity walls cannot be eliminated during the cleaning of dental caries, the use of cavity disinfectants is neccessary. The aim of this study was to evaluate the effect of different disinfectants on the bonding strength of adhesive material polymerised without light. A total of 60 3rd molar teeth, extracted for various reasons, were used in the study. The dentin surfaces were first exposed by raising the enamel tissue with a carbon separator. All the teeth were then embedded in acrylic. After preparation, samples were subdivided into 4 groups of 15 for the use of different disinfectant solutions. Group 1 was defined as the control group and no cavity disinfectant was applied. Tokuyama Universal Bond was applied in the first stage of the restoration. After the adhesive application, the cylindrical discs of 2.3 mm in diameter and 3 mm in length were placed in the middle of the dentin surface. Estelite posterior quick composite was applied, and then polymerised. In group 2, the dentin surfaces were first disinfected for 6 s with ozone gas produced from a Prozone device. In group 3, the dentin surfaces were cleaned for 60 s with 2% chlorhexidine gluconate solution, then dried for 10 s with light pressure air. In group 4, 2.5% sodium hypochlorite was applied to the dentin surfaces as cavity disinfectant. The restoration stages of all the cavities were completed in the same way as for group 1. The samples with completed restoration were then placed in the test device to evaluate the shear bonding strength. Statistical evaluation of the results was made using the Kruskal Wallis and the Mann Whitney U-tests. It was seen that ozone (9.04) and chlorhexidine gluconate (6.59) increased the bonding strength of adhesive resin whereas sodium hypochlorite (2.82) reduced it ($P < 0.05$). Our data showed that chlorhexidine gluconate and especially ozone, can be safely used as cavity disinfectants.

Keywords: Ozone, non-light curing bond, cavity disinfectant

Tooth decay is a multifactorial and infectious disease that destroys the inorganic and organic structure of the tooth with the complex interaction of many host factors such as acid-producing bacteria, fermentable carbohydrates, the tooth, and saliva (1).

There are currently many different methods to eliminate decay. However, the effects of these methods on decay elimination and cavity preparation are still being examined. The basic aim in cavity preparation is to remove all the infected dentin (2). The cavity preparation is applied as a surgical procedure to remove all the infected dentin before using the restorative material. To be able to make a successful restorartion with composite resin, an area must be created during cavity preparation

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that is cleaned as far as possible of contaminated material. Wetness, saliva, blood, or oil contamination from instruments can have a negative effect on the bonding strength between the adhesive and the tooth structure. It is possible for these infectious agents to prevent the composite resin penetration and wettability into the acid treated dentin surface. (3).

One of the most important problems of restorative dental treatment is the incomplete removal of infected dentin tissue, the inadequacy of mechanical cleaning, and that all micro-organisms cannot be eliminated, thereby leading to post operative sensitivity, secondary decay and pulpal inflammation (4).

The application of disinfectant following cavity preparation is an accepted procedure in the prevention of the potential risks formed by bacterial activity. There are several studies that have investigated the bonding of adhesive systems in teeth applied with cavity disinfection methods. While some of these studies have reported negative effects of cavity disinfection on bonding strength, there are also controversial studies.

In the light of all these studies, the use of cavity disinfectant is thought to be an important supplement to restorative treatment. Preparates containing chlorhexidine and benzalkonium chloride are usually used in cavity disinfection. Other recommendations are sodium hypochlorite, hydrogenperoxide, copper sulphate, and iodine-potassium iodide. In the current study, the effects on bonding strength of chlorhexidine, sodium hypochlorite and ozone were examined (5, 6).

Chlorhexidine, which has been used for the last 30 years in dentistry, is an effective method in the chemical control of dental plaque and the prevention of dental caries. The digluconate form of chlorhexidine is used in dentistry. Chlorhexidine digluconate has a bipolar molecular structure and as one of the cationic groups, binds to teeth or mucosa, while it shows the effect of removing other bacteria on the cell wall. With a slow release from the tissues on to which it is bound, chlorhexidine shows long-term efficacy. It is rapidly absorbed onto bacterial surfaces and changes the surface properties of the micro-organism. Membrane permeability is increased by inhibiting cell membrane enzymes at concentrations up to 200 µg/mL (7, 8).

Ozone is a gas composed of 3 oxygen atoms. Ozone has a high oxidation power, and is an effective antibacterial agent in the elimination of bacteria. As it is obtained by fragmentation of oxygen found in the air, it has a volatile structure and returns to the raw material of oxygen after the disinfection procedure (9).

Ozone is a strong oxidant against protozoa, bacteria, fungi and viruses, and can be found in liquid or gas form. In addition to holding glycolipids, glycoproteins and other amino acids, ozone increases membrane permeability by blocking cellular enzyme systems. Consequently, bacteria enter the cell by fragmenting the cell wall and cytoplasmic membrane, and cause the death of micro-organisms. Continuing enzymatic activity of bacteria on the smear layer, which is a source of residual bacteria, is known to be a cause of failure in restoration (7).

Sodium hypochlorite (NaOCl or NaClO) is a chemical compound generated by the combination of cationic sodium and anionic hypochlorite. Hypochlorous acid is seen in the form of sodium salt, which is often used as a disinfectant or bleaching agent. It is currently the most preferred dental disinfectant solution as it has dissolving organic remnants effect, is antiseptic, can be easily diffused to dentin walls at low surface tension, can be easily obtained, and is low-cost (10).

The aim of this study was to evaluate the effect of different disinfectants on the bonding strength of adhesive material polymerised without light.

Materials and Methods

Sample preparation

The study included a total of 60 3rd molar teeth without carries, restorations, cracks or fractures,

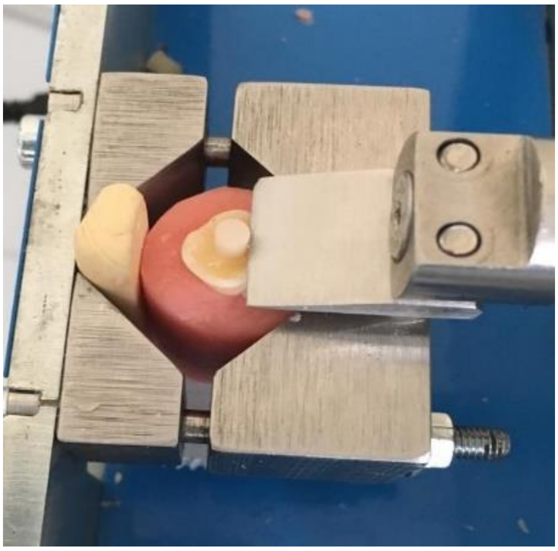

Figure 1. The samples placed on the test device.

which had been extracted for various reasons. After cleaning away soft tissue remnants, all the teeth were kept in distilled water at +4 ˚C until the restoration stage. First the dentin surfaces were exposed by raising the enamel surface with a carbon separator. To be able to obtain smooth dentin surfaces and a standard smear layer, 400 and 600-grain sand papers (Bosh, C355, Switzerland) were used. Then all the teeth were placed in cylindrical moulds 2 x 3 cm in size, containing auto polymerising acrylic.

After preparation, the total 60 samples were separated into 4 groups of 15 for the use of different disinfectant solutions. Group 1 was defined as the control group and no cavity disinfectant was applied. In the first stage of the restoration, non-light polymerising Tokuyama Universal Bond (Tokuyama Dental Corporation, US) was applied. This bonding agent has 2 components, and after mixing equal amounts, it was applied to all the dentin surfaces with a brush. To be able to obtain full polymerisation, air was applied at light pressure for 10 s.

After the adhesive application, the cylindrical discs of 2.3 mm in diameter and 3 mm in length were placed in the middle of the dentin surface. Then Estelite posterior quick composite (Tokuyama Dental Corporation, Tokyo, Japan) was applied using the layering technique inside. Polymerisation of the restorations was completed with an LED light source (GuilinWoodpecker, China, 1100 mW/ cm²).

In group 2 the dentin surfaces were first applied with ozone gas produced from a Prozone device ozon (W&H, Germany) for 6 s. Then the restoration procedures were applied as for group 1, starting with the adhesive material.

In group 3, the dentin surfaces were cleaned with 2% chlorhexidine gluconate solution (Ultradent) for 60 s, then dried with light-pressure air for 10 s. The restoration stages were applied as described for group 1.

In group 4, cavity disinfection of 2.5% sodium hypochlorite solution was applied with a cotton wool pellet to the dentin surfaces. It was left for 30 s to be fully effective and any excess solution was removed with a dry cotton pellet. After disinfection of the cavity, the restoration stages were completed as described for group 1.

The samples with completed restorations were then placed in the test device (MOD Dental, Esetron, Turkey) to evaluate the shear bonding strength (Figure 1). The tip of the device resembling a knife was placed in the interface of the restoration, and the tooth and force was applied at 1 mm/min until the filling separated from the tooth. The results were stated as Newton (N) units, then transformed to megapascal (Mpa), and recorded.

Statistical analysis

Statistical evaluation of the results wa smade using the Kruskal Wallis and MannWhitney U-tests. $P < 0.05$ was considered as statistically significant.

Results

In the statistical analysis of the effect of different disinfectant solutions on bonding strenth of non-light curing adhesive agent, a significant difference was observed between the groups ($P<0.001$) (Table 1).

The statistical analysis results showed that bonding strength was increased with the use of ozone and chlorhexidine gluconate, and it was reduced with the use of sodium hypochlorite (Figure 2).

In the paired comparisons of the groups evaluated with the Mann Whitney U-test

There was a statistically significant difference between the control group and the sodium hypochloride group (P < 0.000) and the ozone group (P < 0.01).

There was also a statistically significant difference between the sodium hypochloride group and the chlorhexidine group (P < 0.001) and the ozone group (P < 0.001).

No statistically significant difference was determined between the chlorhexidine group and the control group (P > 0.05) and the ozone group (P > 0.05).

Discussion

The most important factor affecting the clinical success of a restoration is the bonding strength

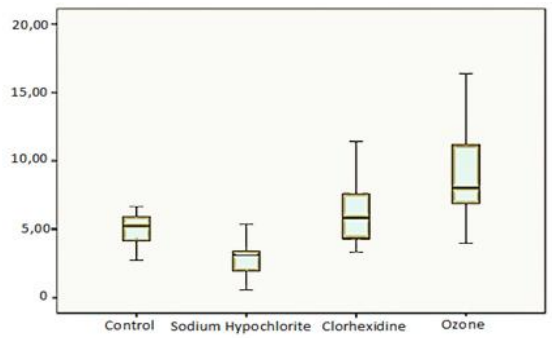

Figure 2. Force application at the interface of tooth and restoration. Graphical representation of the effect of different disinfectant solutions on the bonding strength of the non-light curing adhesive agent.

between the dental tissues and the restorative material. The structure formed by the dental hard tissues and the resin together is known as the hybrid layer. The structural properties of the dentin, preparation of the surface and differences in the method of applying the adhesive system play a large role in the performance of this hybrid structure (11,12).

Current advances in aesthetic dentistry have led to developments in adhesive systems. Many dentin bonding agents have been developed with varying characteristics. A modern classification system has been created for bonding agents according to the application technique and effect mechanism. Thus, there are 3 groups in this classification of total-etch, self-etch and glass ionomer adhesive systems and the common point of all 3 is that they must be polymerised with light. In the current study, Tokuyama universal bonding agent was used, which can be polymerised with light-pressure air without the need for a light source. Tokuyama univeral bond has two components that is compatible with self-etch, selective enamel etch, and total etch techniques, which can be used in direct and indirect restorations. In a study by Sonmez and Akbayoba evaluating the shear bonding strength of a self-etch adhesive, Clearfil Tri-S Bond was seen to have high bonding strength to primary teeth dentin, similar to prime Bond NT (13).

One of the factors with an effect on the bonding of adhesive resins is cavity disinfectants. Previous studies have shown that the bonding

Table 1. The effect of different disinfectant solutions on the bonding strength of non-light curing adhesive agent

Disinfectants	N	Mean	Std. Deviation	95% Confidence Interval for Mean	
				Lower Bound	Upper Bound
Control	15	4.99	1.26	4.29	5.69
Sodium hypochlorite	15	2.82	1.13	2.19	3.45
Chlorhexidine gluconate	15	6.59	3.21	4.81	8.37
Ozone	15	9.04	3.73	6.97	11.11
Total	60	5.86	3.41	4.98	6.75

strength of adhesive resins used together with cavity disinfectants is better, and postoperative sensitivity is prevented. This has been attributed to the wetting effect of disinfectants (14,15).

The main aim of cavity disinfectants is to use the antibacterial effect to eliminate bacteria remaining in the cavity walls, as well as the smear layer and the dentin tubules before restoration. The presence of these bacteria causes inflammation in the pulp, recurrent caries and post operative sensitivity. Due to harmful effects on the pulp of chemicals such as silver nitrate, thymol and phenol that were used in the past, these have been succeeded by biologically compatible disinfectants such as ozone, chlorhexidine gluconate, lasers, hydrogen peroxide, sodium hypochlorite, iodine, and benzalkonium (14,16). In this study, ozone, chlorhexidine gluconate, and sodium hypochlorite were used as they are all in current use.

Although the antibacterial effect of ozone gas on micro-organisms has been proven, conflicting views have been reported about the effect of its use as a disinfectant on bonding strength (16). Several studies have reached the conclusion that ozone gas is successful in the elimination of the cariogenic bacteria, *S. mutans* and *Lactobacillus casei* (16, 17).

Pires et al. evaluated the effect of ozone disinfectant on the bonding strength of total etch and self-etch adhesive systems to enamel and found that ozone had no effect on bonding (18). The effects of disinfectants on silorane-based composites was investigated by Arslan et al., and ozone was reported to have no effect on the bonding with dentin (19). In another study by Schmidlin et al. in 2005, the effects of ozone gas on the bonding strength of enamel and dentin were examined and it was reported that at high doses, ozone had a negative effect on bonding (20).

Cadenaro et al. also examined the bonding strength of bonding agents to enamel and dentin following the application of ozone gas and observed no effect of ozone on bonding. The results of that study showed that Clearfil Protect Bond showed higher bonding strength compared toXeno III, irrespective of ozone application (21).

The effect of 5% sodium hypochlorite on the bonding strength of the Single Bond adhesive system was investigated by Fuentes et al., and the results showed that 5% sodium hypochlorite had reduced hardness by changing the dentin surface properties, and bonding was significantly reduced. It was shown that the reason for this could have been the chemical changes in the dentin surfaces created by 5% sodium hypochlorite (22). In a similar study, Ercan et al. reported that bonding was reduced when sodium hypochlorite was used together with self-etch adhesives, and therefore it should be used with total etch systems (23).

Another cavity disinfectant often used in dentistry as an antibacterial agent is 2% chlorhexidine solution. Chlorhexidine is associated with phosphate groups on the surface of the tooth to increase the surface energy of the dentin. Removal of the smear layer improves the binding of chlorhexidine, while debris release negatively affects resin infiltration (24, 25).

Ricci et al. found no effect of chlorhexidine on the bonding of two-stage total etch adhesive systems to dentin in primary and permanent teeth (26). Similarly, in 2012, Shafiei and Memarpour reported in an adhesive dentistry review that chlorhexidine had no effect on the bonding strength of bonding agents (27). However, while it has been reported that the use of chlorhexidine in dentin affected by decay did not affect the bonding, when restorative material has been included, bonding strength similar to that of the control group has been seen. In addition, in 2006, Totu et al. showed that chlorhexidine significantly reduced the bonding of the bonding agent that modified the smear layer (28).

In this study, the efficacy of 3 different disinfectants was investigated on adhesive material that polimerised without light. The results showed that the bonding strength values of the ozone and chlorhexidine groups were high, and those of the sodium hypochlorite group were significantly low.

In conclusion, the results of this study showed that the bonding strength of adhesive resin was increased by ozone and chlorhexidine gluconate, and decreased by sodium hypochlorite. No statistically significant difference was observed between the ozone and chlorhexidine groups.

Nevertheless, there is a need for further studies to compare the efficacy of ozone to other cavity disinfectants in respect of the bonding strength to dentin.

Conflict of interest

The authors declared no conflict of interest.

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