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Research Article

The Effect of Ozone Gas on Dentin Shear Bond Strength

Abstract

Aim: The aim of this study was to investigate the effect of ozone used as cavity disinfectant on dentin bond strength of resin-based restorative material.

Material and Method: The study included 36 adult 3rd molar teeth removed for surgical reasons. Each tooth was set in a cylindrical mould 2cm in diameter and 3cm high with the dentin surface parallel to the occlusal level and the roots remaining inside, with the help of autopolymerising acrylic. To obtain a standard smear layer, the teeth were filed. The teeth were randomly separated into 4 groups of 9. Ozone gas was applied to the dentin surfaces for 6 seconds (Prozone W&H, Bürmoos, Austria); Group 1 (single Bond Universal, Z250), Group 2 (ozone + single Bond Universal, Z250), Group 3 (Futurabond M, Grandio) Group 4 (Ozone + Futurabond M, Grandio). A 2mm resin layer was applied and polymerised with an LED light source for 20 secs (Light Emitting Diode-Elipar Freelight, 3M ESPE, Germany). The samples were applied with shear force of 1mm/min to breaking point.

Results: No statistically significant difference was determined between the shear bond strength values of all the groups (p>0.05). No statistically significant difference was determined between the shear bond strength values in the paired comparison of the groups (p>0.05). Adhesive type fractures were determined in the majority of all the groups.

Conclusion: The results of this study showed that ozone used for the purpose of disinfection had no negative effect on dentin shear bond strength.

Introduction

The basic aim in the prevention of dental decay is to reduce the factors creating decay and to increase the protective approaches [1]. Complete elimination cannot be provided of the pathogen bacteria in the dentin to remove the decay lesion. When minimally invasive cavity design is planned to prevent excessive substance loss, this problem becomes more important. Bacteria remaining in the dentin tissue under a restoration may cause secondary decay and pulpal inflammation [2]. After physical removal of the decay lesion, the elimination of bacteria and bacterial by-products is necessary [2,3]. In previous studies, cavity disinfectants, antibacterial restorative materials, laser, light-activated disinfection systems and ozone have been used for this purpose [3].

Ozone is a strong oxidant with an antimicrobial effect. In the form of gas or in the liquid phase, it has been accepted that it shows an antibacterial effect by affecting the cytoplasmic membrane and cell wall of bacteria, fungi, protozoa and viruses. For many years it has been used in medicine in the treatment of several diseases [1-6]. With the development of ozone-producing generators, ozone gas is now found in dental practices. It has been reported to have been used in cavity disinfection in restorative treatment [7,8]. However, oxidising substances such as ozone have been reported to have a negatve effect on adhesion and prevent monomer polymerisation [7]. The application of ozone, which is a powerful oxidant, before the bonding process has been reported to reduce the bond strength, as has been seen with whitening agents [4,6]. Despite these previous studies, there has not yet been full clarification of the effects of ozone on the dental hard tissue bond of adhesive restorations.

The aim of this *in vitro* study was to evaluate the effect of ozone gas on shear bond strength in self-etch adhesive systems.

Material and Methods

The study included 36 adult 3rd molar teeth removed for various reasons. Soft tissue remnants were cleaned from the teeth and left in +4˚C distilled water. Each tooth was set in a cylindrical mould 2cm in diameter and 3cm high with the roots remaining inside with the help of autopolymerising acrylic. To obtain smooth dentin surfaces in the crown, enamel tissue was removed with a diamond burr under water cooling so as to be parallel to the occlusal surface. The exposed dentin surface was then filed in a single direction for 30 seconds under water using 200, 400 then 600 density abrasion strips. Following the abrasion process, a standard smear layer was obtained.

The teeth were randomly separated into 4 groups of 9. Ozone gas produced from a Prozone device (W&H, Bürmoos, Austria) was applied to the dentin surfaces with a corona tip in disinfectant mode for 6 seconds from a distance of 1mm. The following materials prepared in accordance with the manufacturer's recommendations were applied to the samples in each group (n=9): Group 1 (single Bond Universal, Z250), Group 2 (Ozone + Single Bond Universal, Z250), Group 3 (Futurabond M, Grandio) Group 4 (Ozone + Futurabond M, Grandio) (Table 1). A 2mm resin layer was applied and polymerized with an LED light source for 20 secs (Light Emitting Diode-Elipar Freelight, 3M ESPE, Germany). After preparation of the samples, they were incubated for 24 hours at 37˚C (Nüve Incubator EN500, Ankara, Turkey). The samples were then placed in an Instron universal test device (Esetron, Turkey) and shear force of 1mm/min was applied to breaking point. The values obtained were recorded as MPa.

In the statistical analysis, results obtained which did not show normal distribution were evaluated with the Kruskal Wallis variance analysis method. In paired comparisons between the groups, the Mann Whitney U-test with Bonferroni correction was used as a multiple comparison test.

The fracture types in the failed surfaces formed by the application of shear force, were determined by examination under stereo microscope at x40 magnification.

Results

The median, minimum and maximum shear bond strength values and fracture type percentages are shown in Table 2 and Figure 1. No statistically significant difference was found between the groups in the shear bond strength of the Kruskal-Wallis test results (p>0.05).

In the paired comparison between the groups, the Mann Whitney U-test with Bonferroni correction was used as a multiple comparison test. No statistically significant difference was found in the shear bond strength in the paired comparison of the groups (p>0.05). In all the treatment groups, mostly adhesive type fractures were seen.

Discussion

Micro-organisms found in the mouth such as gram (+), gram (-) and Candida Albicans are known to be inhibited with the powerful antibacterial effect of ozone. This effect has been reported to be formed by fragmenting the cell membrane of the intracellular components [4]. Ozone has been stated to be more effective than lactobacillus casei (L. Casei) against streptococcus mutans (S. Mutans), which is a significant bacterium in the microflora of decay [9]. After the application of ozone for 60 seconds, almost 99.9% of cariogenic bacteria were seen to have been affected by the ozone gas [10]. The effect of the ozone is known to be related to the duration of the application and the initial concentration of the bacteria [11]. When saliva and biofilm were present in the mouth environment, the effect was seen to be reduced [10]. In studies by Yetkiner et al. [3], which examined the antibacterial effect of ozone on S. Mutans and L. Acidophilus using different ozone generators for different periods, it was reported that 6 seconds of ozone was sufficient as prophylaxis for decay.

In the current study, using the Prozone device which changed oxygen in the air into ozone (W&H, Bürmoos, Austria) (140 ppm, 2lt/mins), the 6 seconds mode recommended for cavity disinfection was applied. In the measurement of the bond strength of the

Table 1: Materials used in the study.

Material	Manufacturer	Contents
Single Bond Universal	3M ESPE, USA	10-MDP, dimethacrylate resins,HEMA, vitrebond compolymer, silane,ethanol,water, filler, photoinitiator
Z250	3M ESPE, USA	Bis-GMA, UDMA, Bis-EMA, Zircon, silica
Futurabond M	VOCO, Germany	Urethandimethacrylate,HEMA, Acetone, Acidic adhesive monomer, 2-hydroxyethylmethacrylate, catalyst
Grandio	VOCO, Germany	

Bis-GMA, bisphenol glycidyl-methacrylate; HEMA,2-hydroxyethylmethacrylate;UDMA, Urethane dimethacrylate; Bis-EMA, ethoxylated bisphenol A dimethacrylate; MDP,methacryloyloxydecyl dihydrogen phosphate.

Table 2: Shear strength values.

Groups	G 1 Single Bond Z250	G 2 Ozone + Single Bond Z250	G 3 Futurabond M Grandio	G 4 Ozone + Futurabond M Grandio
Median	40.5	32.3	32.3	30.5
Min	17.8	21.1	21.1	24.7
Max	52.6	61.1	61.7	61.1

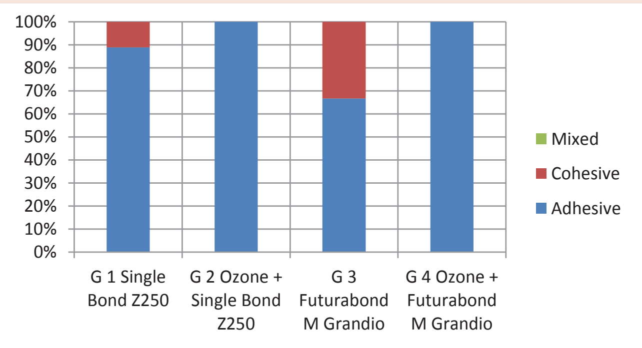

Figure 1: Distribution of Fracture Types in the groups.

materials to the dental tissues, shear bond resistance test is one of the *in vitro* mechanical test methods [12]. In the comparison of the adhesive materials of the current study, the shear bond resistance test was selected as a reliable and practical method [13]. The success of the restoration depends on the strength of the adhesive and tooth interface. To be able to evaluate the long-term efficacy of the adhesive, short-term efficacy must first be defined [14]. Previous studies have reported that the thermal cycle had no effect on the initial shear bond strength of adhesive restorations [13]. Therefore, in the current study, theremal cycle was not applied in the evaluation of the dentin initial shear bond strength. Despite the evidence of the efficacy of ozone gas in decay prophylaxis, the effect on the adhesive layer of application before the bonding procedure has not been fully clarified. In studies by Magni et al. [6], the effect on mechanical characteristics was examined of 120 seconds of ozone gas applied with silorane and 4 different types of adhesive systems, Prime&Bond NT, Excite, Syntac/Heliobond, and it was reported that the ozone had no effect on the mechanical characteristics of adhesives. It was concluded that whatever the chemical components and solvent content, ozone gas treatment did not impair the mechanical features of these adhesives.

As a powerful antioxidant agent, ozone enters into a reaction with all organic materials. By reducing the wettability of the dentin surfaces, plaque formation can be inhibited. In addition, in the same way there is the possibility of transforming organic surface components, such as collagen [15]. These surface changes may negatively affect the bond strength of self-etch adhesive systems [16]. Substances with oxidation properties such as ozone, hydrogen peroxide and carbamide peroxide which are left on the surface of dental tissues have been reported to ultimately negatively affect polymerisation by entering into a reaction with monomer chains which grow during adhesive polymerisation of oxygen molecules [4,17]. Oxygen remaining on the dentin surface can be held responsible for the reduction in bond strength by negatively affecting the bond resistance of the resin materials [4,18].

Dalkılıç et al. [16], investigated the effect of different disinfecting methods of self-etch adhesive systems on the dentin initial bond strength and reported that ozone reduced bond resistance.

In the current study, while a similar effect was expected from ozone, which is an oxidising agent, even though there was a fall in the data obtained of shear bond strength in dentin in comparison with the control group, the difference was not statistically significant. Several previous studies have found similar results, reporting that there was no detrimental efffect on shear strength of ozone used for cavity disinfection [19-21].

Schmidlin et al. [2], reported that the application of 60 seconds ozone on enamel did not affect the bond strength values of restorative materials but in a group to which whitening was applied with 37% hydrogen peroxide, bond values were lower than the ozone and control group. When ozone was used on dentin, there was no statistically significant difference compared to the control group but the values of bond strength were lower in the whitening group.

Pires et al. [19], reported that the application of ozone for 20 secs did not affect enamel adhesion.

Kaptan A and Öztaş N compared the effects of chlorhexidine and ozone on bonding in milk teeth. While no statistically significant difference was determined between the ozone and control groups, the bond strength of the chlorhexidine group was reported to be reduced [20].

The results of previous studies that the use of ozone as a cavity disinfectant did not affect bond strengths are in parallel with the results obtained in the current study.

In previous studies, cohesive fracture types have been characterized by high bond values and adhesive fracture types by low bond values [4,22,23]. In the current study, the majority of fractures in all the groups were adhesive type fractures. In the control groups with high bond resistance, cohesive type fractures were seen at 10-30%.

Conclusion

According to the results of this *in vitro* study, the use of ozone gas prior to self-etch adhesive systems did not cause any statistically significant change in the shear bond strength in dentin tissue.

When the types of fracture were examined, adhesive type fractures were seen in the majority in all the groups which could be due to the reduced bond values, although no significant reduction was seen.

Definitive data on the effects of ozone on bond strength would be supported by *in vivo* experimental animal studies and clinical follow-up.

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