Original Article

Effects of 810 and 970 *nm* Diode Laser on Microtensile Bond Strength of Universal Adhesives to Tooth Dentin

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Abstract

Background: Some previous studies have suggested that laser irradiation improves the bond strength of composite to dentin. This study aimed to assess the effect of 810 and 970 *nm* diode laser on microtensile Bond Strength (µTBS) of universal adhesives to dentin.

Methods: In this *in vitro*, experimental study, the occlusal third of 54 extracted third molars was cut, and they were randomly divided into 9 groups (n=18). In groups 1-3, Tetric N-Bond Universal (TNB), G-Premio Bond (GPB), and Single Bond Universal (SBU) adhesives were applied, respectively and the teeth were built-up by applying three 1-*mm* thick composite increments. The same was performed for groups 4-6 and 7-9 with the difference that they underwent 810 and 970 *nm* diode laser irradiation (0.8 *W*, 20 *s*), respectively, prior to light curing. All the teeth were then sectioned into 1×1 *mm* blocks and their µTBS was measured. Data were analyzed by two-way ANOVA and Tukey test.

Results: The interaction effect of type of bonding agent and laser irradiation on µTBS was not significant (p=0.79). There was a statistical difference between the bond strength of the adhesive systems used (p=0.009).

Conclusion: Laser irradiation of universal adhesives applied by the etch and rinse (E&R) technique using 810 and 970 *nm* diode laser (0.8 *W*, 20 *s*) prior to their polymerization did not increase their µTBS to dentin.

Keywords: Adhesives, Analysis of variance, Curing lights, Dental, Dentin, G-Bond, Lasers, Light-curing of dental adhesives, Polymerization, Semiconductor, Single bond, Tetric

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Introduction

The increasing demand for cosmetic dental procedures such as laminate veneers as well as the emphasis placed on maximum preservation of tooth structure in dental procedures have further added to the significance of dental adhesives and bonding techniques. Attempts are ongoing to simplify the bonding procedure while improving the bond strength of adhesives (1). Accordingly, universal adhesives were introduced to the market to simplify the bonding procedure, which can be applied in Etch and Rinse (E&R), self-etch, and selective-etch modes (2-4). Universal adhesives are composed of acidic monomers and solvent, and their bonding mechanism to dentin is based on their penetration into the hybrid layer. Thus, several strategies have been proposed to improve resin penetration into the hybrid layer such as increasing the surface temperature and warming up the adhesive and composite resin by different methods *e.g.,* laser irradiation (4-6). Nonetheless, achieving a durable high bond strength remains a challenge (6,7). Researchers have tried to change the timing and mode of application of bonding agents to enhance their bond strength to dentin. The effect of thermal alterations on bond strength directed the attention of researchers to laser irradiation for dentin conditioning (5).

Lasers are part of the non-ionizing radiation in the electromagnetic spectrum, and are used in various wavelengths and powers for many dental applications such as oral surgery, soft and hard tissue ablation, and acceleration of wound healing (1).

Considering its affordability and simplicity of use, diode laser is among the commonly used lasers which has the minimum absorption in dentin and maximum absorption in adhesive materials and bonding agents. Evidence shows that laser irradiation can improve the bond strength of adhesives to dentin by thermally affecting them (5,7). According to the literature, laser can increase the bonding temperature and subsequently improve the penetration of primer into the hybrid layer. It can also cause further solvent evaporation, and chemical reaction of acidic monomer. On the other hand, increased penetration of primer into the hybrid layer increases the strength and quality of bond to dentin. Thus, the tensile bond strength and durability of restorations increase, and the risk of secondary caries development and postoperative tooth hypersensitivity is minimized (5,7-13).

microtensile Bond Strength (μTBS) has long been measured as one of the most commonly used techniques for assessment of adhesive bond strength to tooth structure (14). The available studies on the effect of laser irradiation on bond strength have evaluated its effect as a conditioner for dentin and enamel removal (5,11,15), and studies on μTBS of dental restorations subjected to laser irradiation prior to polymerization are limited (8,10,13). Also, the available ones have used different wavelengths of laser and reported controversial results (12). Considering the fact that the performance of universal adhesives and their response to laser irradiation depend not only on major factors (such as the laser energy, time, power, and wavelength), but also on the type of adhesive, this study aimed to assess the effects of 810 and 970 *nm* diode laser on μTBS of several commonly used universal adhesives to dentin prior to their polymerization.

Materials and Methods

This *in vitro*, experimental study was conducted on 54 extracted sound third molars. The minimum sample size was calculated to be 135 assuming alpha=0.05, beta=20%, and study power of 80%. To increase the accuracy of the results, 162 samples were evaluated in this study in 9 groups (n=18). The study protocol was approved by the ethics committee of Shahid Beheshti University of Medical Sciences (IR.SBMU.DRC.REC.1398.193).

The extracted teeth were rinsed and immersed in 1% sodium hypochlorite for 10 *hr*. The periodontal tissue, calculus, and debris were removed by a hand scaler, and the teeth were immersed in distilled water for one week. Next, the occlusal third of the teeth was horizontally cut by a diamond disc (Mashhad Nemov Company, Mashhad, Iran) under water spray. The teeth were then randomly divided into 9 groups.

Three universal adhesives were evaluated in this study namely Tetric® N-Bond Universal (TNB; Ivoclar/Vivadent AG, Lichtenstein), G-Premio Bond (GPB; GC, Japan), and Single Bond Universal (SBU; 3M ESPE, St. Paul, MN, USA). The detailed information of the materials was listed in table 1.

In groups 1-3 (control groups or TNB, GPB, and

Table 1. Specifications of adhesives used in this study

Adhesive system	Manufacturer	Composition
G-premio bond	GC corporation, Tokyo, Japan	10-MDP, 4-META,10-methacryoyloxydecyl dihydrogen thiophosphate, methacrylate acid ester, distilled water, acetone, photo-initiators, silica fine powder
Single bond universal	3M ESPE dental products, 3M center, St. Paul, MN, USA	10-MDP, phosphoric acid ester monomer, HEMA, silane, dimethacrylate, Vitrebond copolymer, filler, ethanol, water, initiators, silane
Tetric N-bond universal	Ivoclar vivadent, Lichenstein	Bis-acrylamide derivative, bis-methacrylamide dihydrogenphosphate, amino acid acrylamide, hydroxyalkyl metharylamide, nano-filler, water, stabilizers

SBU), the exposed dentin was manually polished under water stream with 320-grit silicon carbide abrasive paper (Carbimet Paper Discs, Buehler) to create a standard smear layer. Next, one layer of etchant (Condoc37, FGM, Brazil) was directly applied on the dentin surface, rinsed with copious water after 15 *s*, and dried with gentle air spray for 10 *s* such that the dentin remained slightly moist. Next, one layer of adhesive was applied by a microbrush on the surface and after 10 *s*, it was dried with water- and oil-free air spray for 10 *s*. This process was repeated one more time and light curing was then performed for 10 *s* using a curing unit (Arialux , Apadanatak Co, Tehran, Iran) with 1200 mW/cm^2 power density. FiltekZ250 composite (3M/ESPE, USA) was then applied in three increments (each with 1 *mm* thickness) and light-cured for 20 *s*.

The same process was repeated for groups 4-6 (TNB, GPB, SBU). The only difference was that before curing the bonding agent, the specimens were irradiated with 810 *nm* diode laser (Doctor SMILE, Italy) with 0.8 W power and16 J energy, for 20 *s* in continuous-wave mode at 1 *mm* distance perpendicular to the dentin surface moving at a speed of 1 *mm/s*.

The same process was repeated for groups 7-9 (TNB, GPB, SBU), and the only difference was that the specimens were irradiated with 970 *nm* diode laser (Sirona, Dentsply, USA) with 0.8 *W* power and 16 *J* energy for 20 *s* in continuous-wave mode at 1 *mm* distance perpendicular to the surface. The diameter of the fiber tip was 320 *μm* moving at a speed of 1 *mm/s*. Considering the divergency of the laser beam after irradiating from the fiber tip, the spot size is around 1 *mm*.

After curing the composite, finishing and polishing were performed, and the teeth were immersed in the distilled water at 37*°C* for 24 *hr*. Next, the composite was marked with blue and the crown was marked in red by nail varnish for easier detection after mounting. The teeth were then mounted in auto-polymerizing clear acrylic resin (Acropars Re Marlic, Iran) and sectioned into 1×1 *mm* blocks by a precision automatic micro-cutting machine (Mecatome, Presi, France). Three specimens were obtained from each tooth yielding a total of 18 specimens in each group. The exact dimensions of the blocks were measured by a digital caliper (Mitutoyo, JAPAN), and they were then placed in a microtensile tester (BiscoInc, Schaumburg, IL, USA) and subjected to load at a crosshead speed of 0.5 *mm/min* until fracture (ISO TR 1145). The µTBS was calculated in Mega-Pascal (*MPa*) by dividing the load at fracture in Newton by the bonding surface area in square-millimeters (mm^2). The mean of 18 specimens were used for analysis.

The normality of the data was analyzed using Kolmogorov test. The data were analyzed by SPSS 25 (IBM Corp., Armonk, NY, USA) utilizing two-way ANOVA and post–hoc Tukey test at 0.05 level of significance.

Results

Table 2 presents the mean and standard deviation (SD) of µTBS values in the studied groups. Two-way analysis of variance showed that despite the slight increase in µTBS in the laser-irradiated groups, there was no significant difference between the control and

Table 2. Means and Standard Deviations of µTBS values (MPa) in the Study Groups (n=18)

Groups	Adhesives	Mean± Std. deviation	p-value*
Control	Single bond universal	17.14±5.5	0.001
	Tetric N-bond universal	18.19±7.1	
	G-premio bond	20.52±7.4	
810 *nm* laser	Single bond universal	17.70±6.0	
	Tetric N-bond	18.77±5.6	
	G-premio bond universal	22.91±8.0	
970 *nm* laser	Single bond yniversal	17.88±5.7	
	Tetric N-bond universal	20.86±6.4	
	G-premio bond	21.16±6.5	
Two-Way ANOVA*			

both laser groups (p=0.512). There was a statistical difference between the bond strength of the adhesive systems used (p=0.009). The interaction effect of adhesive agent and laser irradiation on µTBS was not significant (0.793).

Discussion

In the recent years, lasers have been increasingly used in dentistry for different purposes (16,17). Attempts have been made to increase the bond strength of adhesives to tooth structure and decrease the microleakage by laser irradiation of bonding agents prior to their polymerization (18). The general concept behind this idea is that laser irradiation of primer or adhesive increases its temperature, and subsequently the movement of molecules and their flowability, which results in their greater penetration into the dentin hybrid layer. Also, temperature rise results in solvent evaporation and leads to subsequent increase in the degree of polymerization of adhesive. Consequently, the bond strength increases and marginal leakage is minimized (19,20). Thus, this study aimed to assess the effect of 810 and 970 *nm* diode laser on µTBS of several commonly used universal adhesives to dentin prior to their polymerization.

The results showed that despite a slight increase in µTBS in laser groups, the interaction effect of bonding agent and laser irradiation on µTBS was not significant (p=0.512).

Most of the previous studies reported that irradiation of diode laser, and even Nd:YAG laser increased the bond strength and decreased the marginal leakage. However, it should be noted that the majority of these studies used the self-etch technique and only a few used the adhesives in E & R mode (21-23). On the other hand, studies that reported no significant effect of laser mainly used the adhesives in E & R mode (24,25). In addition to the effect of etching mode, variations in laser wavelength, power, distance, duration and energy as well as the type of adhesive can also affect the results (12,26).

Difference between the present results and those of the previous studies may be due to the differences in the method of application and type of adhesive. It is possible that laser irradiation of two steps self-etch bonding agents compensates for their functional shortcomings and improves their bond strength. However, application of the same laser on universal adhesives applied in E & R mode may not increase the bond strength due to the achievement of an optimal bond which cannot be further enhanced. Studies by Ramachandruni *et al* (27), Resaei-Soufi *et al* (28), and Golbari *et al* (29) confirmed this statement; all of them used Clearfil SE bond or universal adhesives in self-etch mode. However, Zabeu *et al* (13) did not report such an increase in bond strength (20,23,27-29). Further studies are required to test this hypothesis by taking into account the effect of type of bonding agent, method of application of adhesive (self-etch or E & R), and laser wavelength.

This study had an *in vitro* design. Thus, generalization of the results to the clinical setting should be done with caution. Also, thermocycling was not performed in this study, which is another limitation. Further studies should perform thermocycling to better simulate the oral environment. Also, future studies should include a no-laser control group and compare it with the laser groups with self-etch and E & R application modes of adhesives to better elucidate this topic.

Conclusion

Within the limitations of this study, the results showed that application of 810 and 970 *nm* diode laser with 0.8 *W* power for 20 *s* on universal adhesives applied in E & R mode prior to their polymerization did not increase their μTBS to dentin.

Conflict of Interest

The authors declare no conflict of interest.

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