

Received:
9-IX-2020

Bond Strength Evaluation of Bulk- fill Composites to Dentin Under Different Surface Treatments

Accepted:
27-X-2020

Published Online:
4-XII-2020

Evaluación de la resistencia adhesiva de las resinas bulk-fill a la dentina con diferentes tratamientos de superficie

Kazım Bas PhD, DDS¹; Ebru Uslu Cender PhD, DDS²

1. Dentopol Oral and Dental Health, Department of Restorative Dentistry, Istanbul, Turkey. <http://orcid.org/0000-0002-5757-5900>

2. Assist. Prof. Dr. Ordu University, Faculty of Dentistry, Department of Restorative Dentistry, Ordu, Turkey. <http://orcid.org/0000-0003-0692-9681>

Correspondence to: Dr. Ebru Uslu Cender - ecender@hotmail.com

ABSTRACT: Purpose: The aim of this study is to compare the shear bond strength of three high-viscosity bulk-fill composite resins applied as single layers of 4mm thickness and of one microhybrid composite resin applied incrementally with a thickness of 2mm on dentin surfaces prepared with different surface preparation methods. Materials and Methods: A total of 132 caries-free human molars whose dentines had been exposed were used. Three groups, each containing 44 teeth, were formed. The acid group was etched with 32% phosphoric acid; laser group was etched with Er, Cr; YSGG laser and the control group was prepared with silicon carbide paper. Following the application of bonding agent, composite resin materials were applied on teeth using teflon moulds of 4x4mm. The samples were then subjected to shear bond strength tests. Two-way variance analysis and Tukey HSD multiple comparison test were applied on collected data. Results: There was a significant difference between surface treatment methods used regarding shear bond strength ($P < 0.001$). The highest shear bond strength values were detected in the "Acid" group while the lowest shear bond strength values were detected in the "control" group. On the other hand, there was no statistically significant difference among composite resins ($P > 0.05$). Conclusions: Laser etching of the dentin tissues is not as effective as acid etching. Bulk-fill composites had similar effects compared with conventional composite resins with regard to bonding strength. More *in vitro* studies supported with clinical data are required to investigate the performance of bulk-fill composites and laser.

KEYWORDS: Bulk-fill composite; Turbo handpiece; Er; Cr; YSGG laser; Shear bond strength.

RESUMEN: Propósito: El objetivo de este estudio es comparar la resistencia adhesiva al cizallamiento de tres resinas compuestas de relleno de alta viscosidad aplicadas como capas individuales de 4 mm de espesor y de una resina compuesta microhíbrida aplicada de forma incremental con un espesor de 2mm en superficies de dentina preparadas con diferentes métodos de preparación de la superficie. Materiales y métodos: Se utilizaron un total de 132 molares humanos sin caries cuyas dentinas habían sido expuestas. Se formaron tres grupos, cada uno con 44 dientes. El grupo ácido se grabó con ácido fosfórico al 32%; el grupo láser se grabó con Er, Cr; el láser YSGG y el grupo de control se preparó con papel de carburo de silicio. Después de la aplicación del agente adhesivo, se aplicaron materiales de resina compuesta en los dientes utilizando moldes de teflón de 4x4mm. A continuación, las muestras se sometieron a pruebas de resistencia adhesiva al cizallamiento. Se aplicó el análisis de varianza bidireccional y la prueba de comparación múltiple Tukey HSD a los datos recogidos. Resultados: Hubo una diferencia significativa entre los métodos de tratamiento de superficie utilizados en cuanto a la resistencia adhesiva al cizallamiento ($P < 0,001$). Los valores más altos se detectaron en el grupo "Ácido" mientras que los valores más bajos se detectaron en el grupo "Control". Por otra parte, no hubo diferencias estadísticamente significativas entre las resinas compuestas ($P > 0,05$). Conclusiones: El grabado láser de los tejidos de la dentina no es tan eficaz como el grabado al ácido. Las resinas de relleno bulk-fill tuvieron efectos similares en comparación con las resinas compuestas convencionales en lo que respecta a la resistencia adhesiva. Se necesitan más estudios in vitro apoyados con datos clínicos para investigar el rendimiento de los composites de relleno y el láser.

PALABRAS CLAVE: Resina de relleno; Pieza de mano turbo; Er; Cr; Láser YSGG; Resistencia adhesiva al cizallamiento.

INTRODUCTION

The physical and chemical properties of composite resins used in dental restorative treatments have been improved by manufacturers (1). Polymerization shrinkage observed in composite resins results in stress between the dental tissue and the restorative material. When this stress exceeds the bonding strength between the dental tissue and the composite resin, adhesion fails (2). Applying resin layers of 2mm thickness into the cavity is an option to reduce polymerization shrinkage but it is a difficult and time-consuming process which is likely to be contaminated by the saliva (3).

The adverse effects of the layering technique eventually led to the invention of bulk-fill composite resins. These composites contain new photoinitiators, more translucency filler, and new-resin monomer systems (4). These inorganic fillers reduce light radiation in the organic matrix interface, which enables high levels of light transmittance and polymerization depth. When applied as a single layer of 4-5mm thickness, bulk-fill composite resin exhibits less polymerization shrinkage compared with the conventional composite resin (3,5,6).

In order to improve the micromechanical bonding by which the composite resins bond to the dental tissue, the bonding area of the dental

tissues must be extended as well. Today, the most common method to achieve this is phosphoric acid etching. However, acid application on dental surfaces may result in sensitivity depending on the proximity of the cavity surface to the pulp (7). The problems and risks of acid application led to the search for different surface preparation methods.

The removal of dental tissues with laser systems and etching of dental surfaces with laser are two recent innovations introduced in dentistry (8). Lasers provide several advantages to the clinician including selective caries removal with minimum tissue loss, less local anesthetic needed, lack of the vibrations and sound of a dental drill, improved patient comfort, and a cavity following laser preparation without a smear layer, which highlighted lasers as an alternative to traditional tooth preparation methods (9). Clinical research showed that pulp was not affected by these applications (10). Therefore, their application has gradually increased in clinics.

CO₂ lasers, Nd: YAG lasers and Erbium lasers are used on dental hard tissues (11). There are two types of Erbium lasers used in dentistry: Er: YAG laser and Er, Cr: YSGG laser. Er, Cr: YSGG lasers are frequently used to modify the surface properties of dental hard tissues. The main advantage of these lasers is that they are absorbed by water molecules at the highest level, which in turn enables faster removal of dental hard tissues (12). The effect of laser beams on the dental surface differs with the wavelength and type of the laser (13).

In vitro tests play a crucial role in evaluating the properties of restorative materials (14). In dentistry, many *in vitro* tests such as shear, microshear, tensile and microtensile tests measure the physical properties of restorative materials (15,16).

The aim of this study was to evaluate the shear bond strength (SBS) of bulk-fill composite resins of high viscosity applied on dental tissues processed with different techniques.

The first null hypothesis of this study was that bulk-fill composite resins applied on dentin tissues would result in a difference in SBS compared with the conventional composite resin group. The second null hypothesis was that there would be no difference between the surface treatments tested with respect to SBS.

MATERIALS AND METHODS

Three different high-viscosity bulk-fill composite resins and one conventional microhybrid composite resin were used in this study. The materials used in this study are presented in Table 1.

SPECIMEN PREPERATION

This study was approved by Ordu University, Clinical Research Ethic Committee (2016/71). A total of 132 human molars were used in this study. Collected permanent molar teeth were freshly extracted due to orthodontic, prosthetic, or periodontal causes were included in the study. The teeth were free of caries, fractures, or restorations. After the extraction, soft and hard tissues remaining on the tooth surface were carefully removed. Following the procedure conducted by Ansari *et al.* (17) and Misilli *et al.* (18) the teeth were stored in 0.5% chloramines-T solution for a week. The teeth were then pumiced and washed. Afterwards, the teeth were stored in distilled water at 4°C for less than 3 months until they were used in the study.

The teeth were cut under water cooling to expose the superficial dentine in the mesio-distal direction with a diamond blade (Isomed,

Buehler) on an automated sectioning device (Presi Metallography, Mecatoma T180, France). After the teeth were rinsed again, they were mounted in acrylic resin with their occlusal surfaces facing upwards, using cylindrical molds (2cm × 3cm × 5cm). Afterwards, the dentin surfaces were wet ground with 100 and 600-grit silicon carbide (SiC) paper (18-21).

The specimens were divided into three groups according to the surface preparation techniques applied: Acid Group, Laser Group and the Control Group. Each group was then divided into four subgroups (n=11) according to the type of composite resin to be applied (Table 2)

The dentin surfaces of the teeth in the Acid Group were etched with 32% phosphoric acid (Scotchbond™ Etchant 3 ml, 3M ESPE, St Paul, MN, USA) for 15s, as instructed by the manufacturer. After etching, surfaces were rinsed with tap water for 20s and were dried with air spray.

An Er,Cr:YSGG laser (Waterlase Iplus MD Turbo, Biolase Technology Inc., San Clemente, CA, USA) was used for surface etching of the teeth in the Laser Group. MX9 turbo tip was used for laser etching. The turbo tip was positioned perpendicular to the surface at a 4mm focal distance in non-contact mode (22). The following parameters were used in the “Bondprep” mode for etching: 2.78 μm wavelength (17) 50 Hz repetition frequency, 4.5 W output power (23), 550 PPS pulse frequency, 60% air pressure level and 40% water pressure level.

In order to reveal the difference between SBS resulting from laser and acid etching, the control group was subjected to polishing only with

wet silicon carbide papers. This method was used by Yazıcı *et al.* (9) and Takada *et al.* (22), as well.

After the etching process was completed, bonding agent (Adper™ Single Bond 2, 3M ESPE, St Paul, USA) was applied, using disposable bonding brushes. It was light cured (Elipar™ S10, 3M ESPE, Seefeld, Germany) for 10 s with a light intensity (between 400 and 515 nm) of 1200 mW/cm².

Teflon molds of 4x4 mm were used to apply composite resins onto the specimens, as Flury *et al.* did (24). Bulk-fill resin was applied as a single layer of 4 mm thickness into the teflon mold and was light cured (Elipar™ S10, 3M ESPE, Seefeld, Germany) according to the manufacturer's instructions. On the other hand, conventional microhybrid composite resin (Filtek™ Z250) was incrementally fabricated in layers of 2 mm thickness. Prior to the SBS tests, the surfaces of the teeth were prepared before adhesive resin application. The teeth were then polymerized and stored in distilled water at 37 °C in an incubator.

SHEAR BOND STRENGTH TEST

The SBS test for the specimens was conducted with a universal testing machine (Autograph AGS-X, Shimadzu Co, Kyoto, Japan). The specimens were placed on the universal testing machine with a specially designed metal apparatus, which had a chisel, to fix the specimens in three dimensions. The crosshead speed was 0.5 mm/min as set by Ansari *et al.* (17). The machine was operated in non-contact mode at minimum focal distance from the surface. The SBS values, which were originally expressed in Newtons (N), were divided by bonding surface area and, were calculated in Megapascals (MPa).

Table 1. Composition of the materials used in the study.

Material	Composition			Colour	Manufacturer and Serial
	Organic Matrix	Inorganic Filler	Filler Ratio wt. %		
Tetric® N-Ceram Bulk Fill	Bis-GMA, Bis-EMA, UDMA	Barium glass, prepolymer, ytterbium trifluoride.	75-77	IVB	Ivoclar Vivadent, Schaan, Liechtenstein V12515
X-tra fil	Bis-GMA, UDMA, TEGDMA	Barium boron aluminum silicate glass.	86-70	U	VOCO, Cuxhaven, Germany 1601243
Filtek™ Bulk Fill Posterior	AUDMA, AFM, UDMA, and 1,12- DDMA	Zirconia/silica cluster filler, ytterbium trifluoride filler.	76.5	A2	3M ESPE, St Paul, MN, USA N753784
Filtek™ Z250	Bis-GMA, Bis-EMA, UDMA, TEGDMA	zirconia/silica, Non-agglomerated/ non-aggregated 20 nanometer surface- modified silica particles.	82	A2	3M ESPE, St Paul, MN, USA N612848
Adper™ Single Bond 2	Ethyl alcohol 25-35%, bisphenol A diglycidyl ether dimethacrylate 10-20%, silanized silica (5 nm with nano-filler) 10-20%, HEMA 5-15%, glycerol 1.3- dimethacrylate 5-10%, acrylic and itaconic acid copolymer 5-10%, diurethane dimethacrylate 1-5%, water <5%				3M ESPE, St Paul, USA N750012

(Bis-GMA), Ethoxylated bisphenol A glycol dimethacrylate (BIS-EMA), Urethane dimethacrylate (UDMA), Triethylene glycol dimethacrylate (TEGDMA), Aromatic dimethacrylate (AUDMA), Additional fragmentation molecules (AFM) Urethane dimethacrylate (UDMA), and 1, 12-dodecane-dimethacrylate (DDMA), 2-hydroxyethyl methacrylate (HEMA).

Table 2. Study groups and surface treatment techniques

Group	Surface Treatment Technique	Number of Samples	Subgroups	Number of Samples(n)
Acid	Scotchbond™ Etchant 3 ml (Phosphoric Acid) (3M ESPE, St Paul, MN, USA) (Content: 32% Phosphoric Acid, Application Time: 15 sec)	N=44	x-tra fil	n=11
			Filtek™ Bulk Fill Posterior	n=11
			Tetric® N-Ceram Bulk Fill	n=11
			Filtek™ Z250	n=11
Laser	Waterlase Iplus MD Turbo (Biolase Technology Inc., San Clemente, CA, USA) Er,Cr:YSGG Laser, MX9 Turbo Headpiece Bondprep Mode (Power: 4.50 W, Repetition Frequency: 50 Hz, Mode: H, Air Cooling: 60%, Water Cooling: 40 %).	N=44	x-tra fil	n=11
			Filtek™ Bulk Fill Posterior	n=11
			Tetric® N-Ceram Bulk Fill	n=11
			Filtek™ Z250	n=11
Control	No surface treatment	N=44	x-tra fil	n=11
			Filtek™ Bulk Fill Posterior	n=11
			Tetric® N-Ceram Bulk Fill	n=11
			Filtek™ Z250	n=11

STATISTICAL ANALYSIS

The data obtained from the study were evaluated with Two-Way Analysis of Variance (ANOVA) for SBS. According to Power and Sample Size Test, the sample size was determined as five for each group according to the sample size ($\alpha = 0.05$) and 95% test power, similar to the in-vitro study by Usumez *et al.* (25). A total of 132 (12x11) specimens were included in the study for possible problems.

The data collected in this study were first evaluated for normality using Shapiro-Wilk normality test (SPSS version 15.0; SPSS, Inc., Chicago, IL, USA). The data were then evaluated with Two-Way Variance Analysis. Tukey's HSD Multiple Comparison test was used to compare differences among the mean values of the groups.

RESULTS

The bond strength values had a normal distribution for the composite resin types and surface treatment methods used in the study ($P > 0.05$) (Table 3). Table 4 and Table 5 show the mean bond strength values and standard deviations in MPa.

The variance analysis applied on the data showed statistically significant differences among the surface treatment methods for SBS values ($P < 0.001$).

Figure 1 presents the SBS values of the composite resins for surface preparation methods. On the other hand, there was no statistically significant difference between the composite resin materials ($P = 0.199$) and the K*U interaction groups ($P = 0.449$) for SBS values. Figure 2 shows the comparison of different surface preparation methods applied for each composite resin material.

The highest SBS values were detected on acid-etched specimens. Of these, Filtek™ Z250 (3M ESPE, St Paul, MN, USA) had the highest SBS (15.64 ± 2.82 MPa). As for the bulk-fill composite resins, the highest SBS value (15.48 ± 4.44 MPa) was found in X-tra fil (VOCO, Cuxhaven, Germany). However, there were no statistically significant differences among the composite resin types with respect to SBS values ($P = 0.449$).

The laser-etched specimens had statistically significant lower SBS values compared with those of the acid-etched specimens ($P < 0.001$). Of all the laser-etched specimens, X-tra fil (VOCO, Cuxhaven, Germany) showed the highest SBS (13.70 ± 3.48 MPa). The laser-etched group had statistically significant higher SBS values compared with those of the control group which was not subjected to any surface preparation ($P < 0.001$).

There were no statistically significant differences among the composite resin types with respect to the SBS values neither in the laser-etched group nor the control group ($P = 0.449$).

Table 3. Shapiro-Wilk normality test results.

Group	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Tetric® N-Ceram Bulk Fill	.125	33	.200*	.903	33	.006
X-tra fil	.117	33	.200*	.936	33	.053
Filtek™ Bulk Fill Posterior	.107	33	.200*	.968	33	.429
Filtek™ Z250	.159	33	.034	.941	33	.075

*. Lower bound for statistically significant difference.

^a. Lilliefors Significance Correction.

Table 4. Tukey's Multiple Comparison Test Results

Composite Resins	Surface Preparation Methods			
	Acid	Laser	Control	General
X-tra fil	15.48 ± 4.44	13.70 ± 3.48	6.27 ± 1.20	11.81 ± 5.18
Filtek™ Bulk Fill Posterior	13.19 ± 3.96	13.06 ± 3.21	5.84 ± 1.52	10.70 ± 4.58
Tetric® N-Ceram Bulk Fill	13.43 ± 3.92	11.54 ± 1.57	6.19 ± 0.92	10.39 ± 3.94
Filtek™ Z250	15.64 ± 2.82	12.13 ± 3.16	6.02 ± 1.35	11.26 ± 4.74
General	14.44 ± 3.87 a	12.61 ± 2.97 b	6.08 ± 1.23 c	11.04 ± 4.61

a,b,c show differences among application groups on the same line (P<0.05).

Table 5. Two-Way Analysis of Variance Test.

Sources of Variation			
	Composite Resin (K)	Application (U)	K*U
P-values	0.199	<0.001	0.449

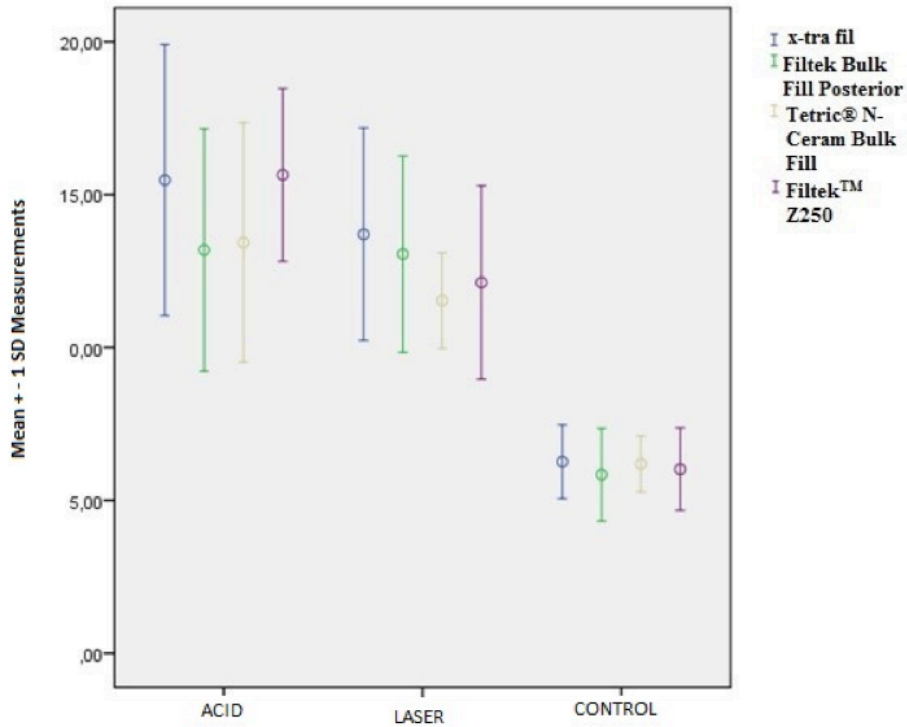


Figure 1. Graphics for composite resins according to surface preparation techniques (Mean ± standard deviation).

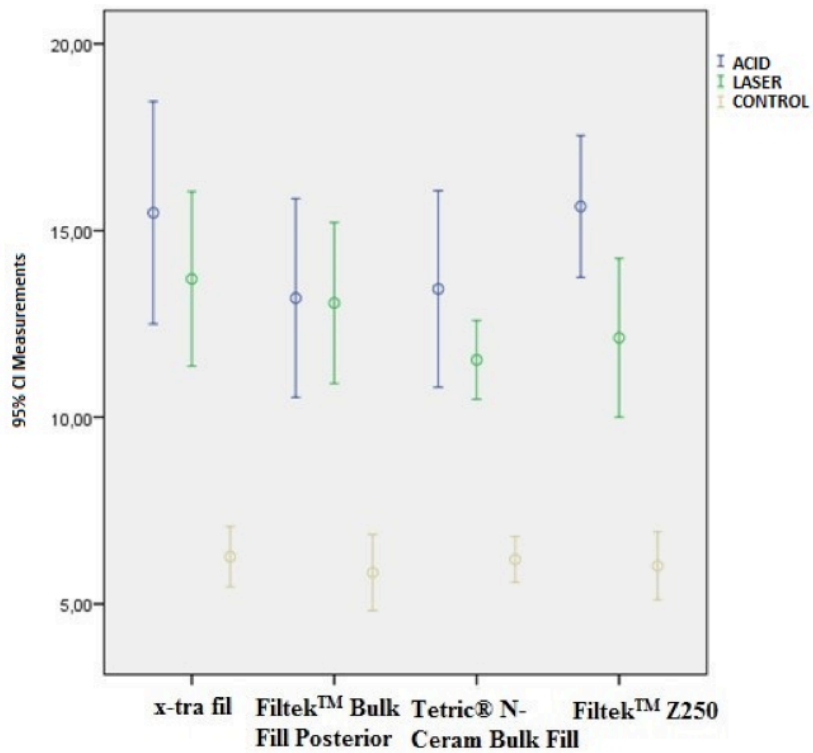


Figure 2. Graphics for each composite resin according to surface preparation techniques (Mean ± standard deviation).

DISCUSSION

The variance analysis conducted showed that there was a statistically significant difference between surface preparation techniques with respect to SBS. Of all the composites used in the study, the highest SBS values were found in acid-etched teeth while the lowest SBS values were measured in the control group. Although the laser-applied teeth did not have SBS as high as those of the acid-etched teeth, they still had significantly higher SBS values compared with the control group.

There is no consensus in literature as to the effectiveness of using only laser in surface etching. It was showed that Er,Cr:YSGG laser and Er:YAG laser had similar effects as acid application on teeth tissues, causing no apparent thermal damage and that they formed rough surfaces which might enhance the bond strength of resin-based materials and adhesive restorations (26, 27).

Olivi *et al.* (28) reported that widening the application surface with a turbo handpiece produced exclusively for Er,Cr:YSGG laser could facilitate the clinical use of Er,Cr:YSGG laser (28).

In this study, a two-step etch-and-rinse adhesive system was used to observe the effect of laser etching of dental surfaces on bonding, as used by Carvalho *et al.* (29).

A study of the literature revealed that the number of studies evaluating the resin bond strength of dentin-bulk fill composites applied with Er,Cr:YSGG laser including a turbo handpiece is limited.

Takada *et al.* (22) compared the effectiveness of several bonds on dentin surfaces prepared with laser with a turbo handpiece (MX5). They used only silicone carbide sandpaper in the control group. They found that pretreating the dentin

surfaces with phosphoric acid or phosphoric acid and sodium hypochlorite combination prior to Er,Cr:YSGG laser application increased the bond strengths of composite resins (22). This result complies with our findings.

Ansari *et al.* (17) recommended the use of Er,Cr:YSGG laser in combination with phosphoric acid for cavity preparation or surface etching. Jeevarathan *et al.* (30) reported that mean SBS of Acid etching Group was significantly higher than the mean SBS of Laser etching Group. The study conducted by Carvalho *et al.* (29) reported similar results. These findings support our findings.

In a study conducted by Lee *et al.* (31), it was found out that Er,Cr:YSGG laser irradiation followed by acid-etching increased tensile bond strength as much as bur cut / acid-etched dentine.

Lee *et al.* (31) also reported that the peritubular dentin which protruded from the surrounding intertubular dentin resulted from the high mineral content and low water content of peritubular dentin. On the other hand, Er,Cr:YSGG laser application followed by acid-etching removed the mineral content of dentin and widened dentinal tubule orifices. After acid-etching, surfaces seemed significantly smooth (31).

Lee *et al.* (31) found that the bond strength of laser-ablated human dentin was statistically lower than those of other groups. They reported that this might result from the fact that Er,Cr:YSGG laser was not able to selectively remove hydroxyapatite crystallites without any harmful effect on the collagen fiber network. When acid-etching was not applied after laser application on dentin, collagen fiber was not totally exposed. Therefore, the quality of the hybrid layer was not adequate in laser-ablated dentin (31).

Demineralization occurs during the application of acid on dentin tissues and, removal of

hydroxyapatite from intertubular collagen results in orifices within the tissue. Thus, with increased microporosity, the bonding of the adhesive to be applied increases. In addition, it was reported that acid applied on dentin tissue removed the smear layer, ultimately increasing the bond strength (32).

Similar to our study, these studies showed that acid application resulted in better bonding compared with laser etching and that laser application, which can not be an alternative for acid, should be used in combination with acid. However, there are studies (Sung *et al.* (33)) in literature with different results compared with our study.

As reported by Ansari *et al.* (17), these discrepancies among the studies may result from the physical parameters of the laser, the material used to fill the cavities or the combination of laser-etched surface with or without acid etching.

In most of these studies, etching was achieved using Er,Cr:YSGG laser with a standard handpiece. The difference between the turbo handpiece and the standard handpiece is that the turbo handpiece, which uses turbo tips with spot diameters of 500, 700 and 900 microns, enables a focal distance of 3-5 mm off the tissue. In the light of this information, new studies comparing conventional lasers with Er,Cr:YSGG lasers with turbo handpieces are required.

In the present study, no statistically significant difference among the composite resin materials for SBS was found, which was similar with the results of Ilie *et al.* (34), Omran *et al.* (35) and Seyhan Cezayirli *et al.* (36).

Moreover, it was observed that filler content increased when translucency decreased. This results from the fact that light transmission is tightly depend on material opacity. Therefore, it can be deduced that the behaviour of bulk fill composites can not be predicted. Bulk fill

composites can have a homogenous adhesion interface which can produce highly probable cohesive failure despite increased increment thickness. Accordingly, high mean SBS values of bulk increments can be achieved in comparison with conventional composite resins (35).

Bond strength is affected by many factors such as the type of acid/adhesive used, application time and chemical structure of the dentin (37).

The variants of the shear bond strength test were elasticity module of the restorative material bonded and the diameter of the sample; thickness of the adhesive resin; dentin depth (deep or superficial); type and contact point of the material bonded and speed of the test machine's blade (38).

The elasticity module values of the restorative materials used in our study are as follows: Dentin (18,6 GPA); Filtek Z 250 (24,494 Gpa), Xtrafil bulk (21,6 Gpa), Filtek Bulk (17,2 Gpa), Tetric N (10 GPA). These values comply with those reported by Mandava *et al.* (39), Yamanel (40) and Rizzante *et al.* (41). In general, SBS values found in our study comply with these elasticity module values. Although the SBS values of the composites found in our study differ, these differences are not statistically significant.

Inadequate polymerization can result in excessive residual monomers, problems in bonding, leakage and fractures (42,43).

Benetti *et al.* (44) found that Tetric EvoCeram Bulk-Fill showed a higher depth of cure compared with the conventional resin composite. In addition, it was reported that bulk-fill resin composites had a higher depth of cure. The difference between the two restorative materials was referred to the developments in their initiator system and increased translucency. As for Tetric EvoCeram Bulk-Fill, the increased depth of cure was achieved with the addition of a new initiator together with the

camphoroquinone/amine initiator systems. This new initiator is Ivocerin. It effectively increases the depth of cure in Tetric EvoCeram Bulk-Fill in comparison with its regular nanohybrid resin based composite pendant Tetric EvoCeram since the chemical composition and the filler systems in both materials are comparable (21).

Except for the specific properties of the monomer, higher-molecular weight monomer systems usually exhibit a lower decrease of the degree of conversion with increasing incremental thickness in comparison with regular resin composite based on bisphenol-A-dimethacrylate (34). Filtek Bulk Fill consists of a high molecular weight aromatic dimethacrylate (AUDMA) and UDMA (45).

The fact that Tetric N Ceram and Filtek Bulk Fill, despite their low elasticity modules, had similar results as the other composite resins can be explained by these properties.

The commercially available bulk-fill resin composites must be placed in increments of 4mm into deep posterior cavities. This 4mm thickness must be strictly applied in order to avoid significant decreases in SBS values and subsequent adverse effects on dentin bond strength (35).

Misilli *et al.* (18) reported that bulk-fill composites can be applied in layers of 4mm in spite of the fact that the studied composites had better performance with a thickness of 2mm.

While the higher polymerization depth of bulk-fill composite resins compared with conventional composite resins is achieved with the high translucency of the materials, reduced polymerization stress is associated with improvements in organic matrix and inorganic filler content (46).

Bulk-fill composites had similar bond strengths with conventional composites thanks to their feature which enabled them to be placed in

increments of 4mm. The conventional composite resin, on the other hand, is polymerized in increments of 2mm, which prevent a decrease in bond strength.

More *in vitro* studies supported with clinical data are required to investigate the performance of bulk-fill composites.

There were several limitations in our study. One of our limitations was that thermal cycle was not used to evaluate the long-term results of aging in our study. It was reported that SBS might also be affected by thermal cycle. The second limitation of our study was that the laser device was used according to the instructions of the manufacturer. Laser-etching with different parameters of the turbo handpiece might affect the SBS. A third limitation of our study was that scanning electron microscope (SEM) was not used to detect failure modes.

CONCLUSION

Based on the findings of this study, the following conclusions were drawn:

1. Laser etching of the dentin tissues is not as effective as acid etching. An improvement in lasers is required in order to enhance their effect on hard tissues, which in turn can present it as an alternative to acid.
2. As for SBS, bulk-fill composites can be safely used like conventional composites.

ACKNOWLEDGEMENTS

This study was orally presented in the 22nd International Scientific Congress of Restorative Dentistry Association. We would like to thank Ordu University, Scientific Research Coordination Unit for their financial support of our study (Project No: TU-1605). We would also like to thank Prof. Dr. Soner ÇANKAYA for statistical analyses.

REFERENCES

1. Kwon Y., Ferracane J., Lee I.B. Effect of layering methods, composite type, and flowable liner on the polymerization shrinkage stress of light cured composites. *Dent Mater.* 2012; 28: 801-809.
2. Kim R.J., Son S.A., Hwang J.Y., et al. Comparison of photopolymerization temperature increases in internal and external positions of composite and tooth cavities in real time: Incremental fillings of microhybrid composite vs. bulk filling of bulk fill composite. *J Dent.* 2015; 43 (9): 1093-1098.
3. Kim R.J., Kim Y.J., Choi N.S., et al. Polymerization shrinkage, modulus, and shrinkage stress related to tooth-restoration interfacial debonding in bulk-fill composites. *J Dent.* 2015; 43 (4): 430-439.
4. Karadas M., Hatipoglu O., ER H., et al. Influence of different light-curing units on monomer elution from bulk fill composites. *J Adhes Sci Technol.* 2018; 32, (23): 2631-2646.
5. Ilie N., Bucuta S., Draenert M. Bulk-fill resin-based composites: an in vitro assesment of their mechanical performance. *Oper Dent.* 2013; 38 (6): 618-625.
6. Bucuta S., Ilie N. Light transmittance and micro-mechanical properties of bulk fill vs. conventional resin based composites. *Clin Oral Invest.* 2014; 18 (8): 1991-2000.
7. Yousaf A., Aman N., Manzoor M.A., et al. Postoperative sensitivity of self etch versus total etch adhesive. *J Coll Physicians Surg Pak.* 2014; 24 (6): 383-6.
8. Dunn W.J., Davis J.T., Bush A.C. Shear bond strength and SEM evaluation of composite bonded to Er: YAG laser-prepared dentin and enamel. *Dent Mater.* 2005; 21 (7): 616-24.
9. Yazici R., Karaman E., Tuncer D., et al. Er A. Effect of an Er,Cr:YSGG laser preparation on dentin bond strength of a universal adhesive. *J Adhes Sci Technol.* 2016; 30 (22): 2477-2484.
10. Kilinc E., Roshkind D.M., Antonson S.A., et al. Thermal safety of Er:YAG and Er,Cr:YSGG lasers in hard tissue removal. *Photomed Laser Surg.* 2009; 27 (4): 565-70.
11. Dederich D.N., Bushick R.D. Lasers in dentistry: separating science from hype. *J Am Dent Assoc.* 2004; 135 (2): 204-12; quiz 229.
12. Hossain M., Nakamura Y., Yamada Y., et al. Effects of Er,Cr:YSGG laser irradiation in human enamel and dentin: ablation and morphological studies. *J Clin Laser Med Surg.* 1999; 17 (4): 155-9.
13. Moritz A., Schoop U., Strapl M., Wintner E., Moritz A., Beer F., et al. Cavity preparation. *Oral Laser Application Berlin: Quintessenz.* 2006; 75-136.
14. Van Meerbeek B., De Munck J., Mattar D., et al. Microtensile bond strengths of an etch and rinse and self-etch adhesives to enamel and dentin as a function of surface treatment. *Oper Dent.* 2003; 28 (5): 647-60.
15. Marshall G.W. Dentine microhardnes and characterisation. *Quintessence Int.* 1993; 24 (9): 606-17.
16. Versluis A., Tantbirojn D., Douglas W.H. Why do shear bond tests pull out dentin? *J Dent Res.* 1997; 76 (6): 1298-307.
17. Ansari Z.J., Fekrazad R., Feizi S., et al. The effect of an Er,Cr:YSGG laser on the micro-shear bond strength of composite to the enamel and dentin of human permanent teeth. *Lasers Med Sci.* 2012; 27 (4): 761-5.
18. Misilli T., Gönülo N., Cabadağ Ö.G., et al. The effect of curing lights and modes on dentin bond strength of bulk-fill composites applied in different thickness. *J Adhes Sci Technol.* 2019, 33 (10): 2281-91
19. Tulga A., Saraç D. Effects of Dentin Surface Treatments on Hypersensitivity to Bond

- Strength of Restorations: An In Vitro Study. *Int J Periodontics Restorative Dent.* 2015; 35 (5): e66-e74
20. Shamrani A.S.A. An in-vitro assessment of micro-shear bond strength of a nano adhesive to dentin with different types of composite restorative systems. *J Dent Health Oral Disord Ther.* 2016; 5 (2): 240-244.
 21. Colak H., Ercan E., Hamidi M.M. Shear bond strength of bulk- fill and nano-restorative materials to dentin. *Eur J Dent.* 2016, 10 (1): 40-45.
 22. Takada M., Shinkai K., Kato C., et al. Bond strength of composite resin to enamel and dentin prepared with Er,Cr:YSGG laser. *Dent Mater J.* 2015; 34 (6): 863-71.
 23. Obeidi A., McCracken M.S., Liu P.R., Litaker M.S., Beck P., Rahemtulla F. Enhancement of bonding to enamel and dentin prepared by Er,Cr:YSGG laser. *Lasers Surg Med.* 2009 Aug; 41 (6): 454-62.
 24. Flury S., Peutzfeldt A. and Lussi A. Influence of increment thickness on microhardness and dentin bond strength of bulk fill resin composites. *Dent Mater.* 2014; 30 (10):1104-12.
 25. Usumez A., Aykent F. Bond strengths of porcelain laminate veneers to tooth surfaces prepared with acid and Er,Cr:YSGG laser etching. *J Prosthet Dent* 2003; 90: 24-30.
 26. Martínez-Insua A., da Silva Dominguez L., Rivera F.G., et al. Differences in bonding to acid-etched or Er: YAG-laser-treated enamel and dentin surfaces. *J Prosthet Dent.* 2000; 84 (3): 280-8.
 27. Ceballos L., Toledano M., Osorio R., et al. ER-YAG laser pretreatment effect on in vitro secondary caries formation around composite restorations. *Am J Dent.* 2001; 14 (1): 46-9.
 28. Olivi M., Olivi G. *Physics of Laser. Lasers in Restorative Dentistry*, Berlin: Springer; 2015; 39-50.
 29. Carvalho A.O., Reis A.F., de Oliveira M.T., et al. Bond Strength of Adhesive Systems to Er, Cr:YSGG Laser-Irradiated Dentin. *Photomed Laser Surg.* 2011; 29 (11): 747-52.
 30. Jeevarathan J., Aravind I. , Ponnuduraiet A., et al. Comparative Evaluation of Shear Bond Strength of Composite Resin Bonded to Acid Etched and Lased Primary Enamel (Er, Cr: YSGG). *Indian J Public Health Res Dev.* 2019, 10 (6): 171-75.
 31. Lee B.S., Lin P.Y., Chen M.H., et al. Tensile bond strength of Er,Cr:YSGG laser-irradiated human dentin and analysis of dentin-resin interface. *Dent Mater.* 2007; 23 (5): 570-8.
 32. Pashley D.H., Carvalho R.M. Dentin permeability and dentin adhesion. *J Dent.* 1997; 25 (5): 355-72.
 33. Sung E.C., Chenard T., Caputo A.A., et al. Composite resin bond strength to primary dentin prepared with Er, Cr:YSSG laser. *J Clin Pediatr Dent.* 2005; 30 (1): 45-9.
 34. Ilie N., Schoner C., Bucher K., et al. An in-vitro assessment of the shear bond strength of bulk-fill resin composites to permanent and deciduous teeth. *J Dent.* 2014; 42 (7): 850-5.
 35. Omran T.A., Garoushi S, Abdulmajeed AA, et al. Influence of increment thickness on dentin bond strength and light transmission of composite base materials. *Clin Oral Investig.* 2017; 21 (5): 1717-1724.
 36. Seyhan Cezairli N., Küçükekenci A.S., Başoğlu H. Evaluation of Shear Bond Strength Between Orthodontic Brackets and Three Aged Bulk Fill Composites. *ODOVTOS-Int. J. Dent. Sc. | No. 21-3, 89-99, 2019.*

37. Guler C., Keskin G., Grgen V.A., et al. St Diřlerinde Farklı Renklerdeki Kompomerlerin Mikrogerilim Baėlanma Dayanımlarının Deėerlendirilmesi. *Turkiye Klinikleri J Dental Sci* 2013; 19 (2): 106-12
38. ElAraby A.M., Talic Y.F. (2007). The effect of thermocycling on the adhesion of selfetching adhesives on dental enamel and dentin. *J Contemp Dent Pract*, 8 (2): 17-24.
39. Mandava J., Vegesna D.P., Ravi R., Boddeda M.R., et al. Microtensile bond strength of bulk-fill restorative composites to dentin. *J Clin Exp Dent*. 2017;9(8):e1023-8.
40. Yamanel K. Farklı restoratif materyallerle restore edilen abraksiyon lezyonlu diřlerde oluřan streslerin 3 boyutlu sonlu elemanlar analizi kullanılarak deėerlendirilmesi. *A.. Diř Hek. Fak. Derg.* 45 (3) 115-125, 2018.
41. Rizzante F.A.P., Mondelli R.F.L., Furuse A.Y., et al. Shrinkage stress and elastic modulus assessment of bulk-fill composites. *J Appl Oral Sci*. 2019; 27: e20180132.
42. Wieczkowski, G.Jr., Joynt R.B., Klockowski R., et al. Effects of incremental versus bulk fill technique on resistance to cuspal fracture of teeth restored with posterior composites. *J Prosthet Dent*. 1998; 60 (3). 283-287.
43. Yap A.U. Effectiveness of polymerization in composite restoratives claiming bulk placement: impact of cavity depth and exposure time. *Oper Dent*. Mar-Apr 2000; 25 (2): 113-20.
44. Benetti A.R., Havndrup-Pedersen C., Honoré D. et al. Bulk-fill resin composites: Polymerization contraction, depth of cure, and gap formation. *Oper Dent*. 2015; 40: 190-200.
45. <https://multimedia.3m.com/mws/media/9766340/filtek-bulk-fill-posterior-restorative-technical-product-profile.pdf>
46. Leprince J.G., Palin W.M., Vanacker J., et al. Physicomechanical characteristics of commercially available bulk-fill composites. *J Dent*. 2014; 42 (8): 993-1000.



Attribution (BY-NC) - (BY) You must give appropriate credit, provide a link to the license, and indicate if changes were made. You may do so in any reasonable manner, but not in any way that suggest the licensor endorses you or your use. (NC) You may not use the material for commercial purposes.