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Original Article

The Effect of Using Composite Primers, Silane and Surface Roughening on the Shear Bond Strength of Metal Brackets bonded to Old Composites

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Abstract

Background: One of the effective factors in successful orthodontic treatment is the use of appropriate bond between the orthodontic bracket and surface of the composite restoration. The aim of this study was to evaluate the effect of using composite primers, silane, and surface roughening on the shear bond strength of metal brackets bonded to old composites.

Methods: In this laboratory study, 90 composite disks (Z350 3M) measuring 4 by 6 mm were kept in distilled water for 1 week and subjected to 5000°C heating rotation (rpm). These samples were divided into 6 groups based on the use of composite primer, surface roughening, and silane as follows: Group 1 (Control): old composite+37 % acid etching, Group 2: Old composite+37% acid etching+20 s cure. Group 3: Old composite+37% acid etching+5 s air-drying, Group 4: Old composite+acid etching+rubbing, Group 5: Old composite+roughing with diamond bur, Group 6: Old composite+Acid etching+roughing with diamond bur metal brackets were attached to the specimens and the specimens were immersed in water and in a thermal rotation system of 5000 rpm for 1 week. The shear bond strength of the brackets was measured.

Results: The highest and the lowest shear bond strength values were found in the fourth and control groups, respectively, indicating a significant difference across all groups ($P=0.001$). In this regard, the results of least significant difference (LSD) test also showed that the mean shear bond strength of orthodontic brackets in the control group was significantly lower than that observed in other experimental groups, but without significant difference across the pointed groups.

Conclusions: The use of surface roughness, composite primer, and silane together do not have a cumulative effect on the increase of the bond strength between old composite and orthodontic brackets. However, the use of each alone can increase the shear bond strength.

Keywords: Aged Composites, Orthodontic Brackets, Bond Strength

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Introduction

There are many reasons that increase the need for orthodontic treatment among patients. One of the most important of them is beauty (1). Beauty affects a person's self-esteem and behavior in society and has a direct impact on the positive judgment of others about him. Generally, those who have aligned occlusion compared to their peers have a better job and social status as well as a successful life (2-4). Today, the need for tooth-colored restorations has increased more than ever (5). One of the most important reasons is the beauty that has caused patients to avoid amalgam restorations and prefer composite restorations (6-9). Composite restorations were first used in dentistry in 1936 and their superiority over amalgam and porcelain restorations was quickly proved (10). Composite restorations are 76% to 92% successful in posterior tooth restoration, with significant differences in color matching, marginal cohesion, tissue surface features, and anatomical shape (11,12). Moreover, composite restorations do not contain toxic substances such as mercury compared to amalgam restorations and do not require conventional machining. For this reason, composite restorations are widely used in repairing extensive caries following trauma, peat and fissures and restorative veneers. Therefore, more composite restorations are used in restorative treatments of anterior teeth and the buccal surface of posterior teeth

(13). One of the most important challenges in orthodontic treatment of patients with composite restorations is the insufficient bonding strength of orthodontic brackets bonded to composite restorations compared to enamel. For this reason, the importance of bonding between dental restorations and orthodontic brackets is already evident (14). Today, various methods are provided to prepare the surfaces of old composites and solve the bonding problems of orthodontic brackets. The aim of all these methods is to increase the friction and roughness of the old composite surface to improve the mechanical bond with the new composite. The purpose of using bonding is to increase the surface moisture, which is divided into two groups of mechanical methods (using diamond burs (6) or abrasion with abrasive particles such as sand or CO_2 lasers) and chemical methods (phosphoric acid and hydrofluoric acid with different bonding resins) (15-17). One of the chemical methods is to add bonding material. The use of bondings can improve the tensile strength between orthodontic brackets and composite restorations (18). In fact, orthodontic treatments, unlike restorative treatments, do not require strong bonding and tensile bond strength of 6 to 10 MPa is sufficient for this treatment plan (19). It is very important to use bondings to improve the connection between the old and new composites because it is time-consuming and costly to change them frequently and re-tighten the brackets (20). Today, new self-adhesive materials have been introduced with the ability of optimal bonding between orthodontic brackets and hard materials such as amalgam, composite, and porcelain (21). However, some studies have emphasized the replacement and use of appropriate brackets instead of bonding (22). The use of a suitable restorative material can also help to prevent some problems. The use of fluoride-releasing composites prevents caries under the brackets and thus reduces the strength between the bracket and the restoration.

Methacrylate monomers used in the preparation of the resin composite can improve the bond strength between the layers (23). These molecules are located on the surface of the oxygen inhibitor in the polymerized resin of the composite and help to gradually regenerate the composite. The difference in bond strength between old composites and new composites is equal to the shear bond strength (24). However, for some reason, old composites do not have this amount of surface methacrylate due to abrasion and salivary contamination. . Another hypothesis claims that carbon double bonds between substrate and and vinyl groups of composite primers decreases over times (25). Therefore, the surface properties of old composites are completely different from new composites. Additionally, the composite resins in the oral cavity are subject to hydrolytic structural degradation over time under the influence of intraoral microorganisms (26). For this reason, conventional composites used for orthodontic bracket bonding often fail.

The bonding system used in orthodontic brackets must be able to withstand the forces of orthodontic wires as well as the functional forces of the mouth (27). Some studies have tried to evaluate the shear bond strength between orthodontic brackets and amalgam and porcelain restorations, but few studies have evaluated the shear bond strength between orthodontic brackets and composite restorations. The present study aimed to evaluate the shear bond strength between old composite restorations and orthodontic brackets.

Materials and Methods

The present study is an in vitro laboratory study including 90 composite disks with dimensions of 6 × 4 mm that were prepared using Teflon bonds. In this regard, composite resins (Z350 3M, ESPE, St Paul, Minnesota, USA color (A2)) was used. After placing the Teflon bond on the glass slab, the composite was placed inside the generator to a thickness of 2 mm and cured with a light curing device (Coltolux 75, Coltene, USA) for 20 seconds. The second composite layer was added in the same way. Before curing, a piece of glass was pressed to smooth the composite surface and remove excess material to prevent the formation of an oxygen-inhibition layer on the composite surface. After removing the glass, the composite was cured again for 20 seconds. All discs were prepared by an operator. Then, a light intensity of 750 mW/cm² was used, and the samples were cured from both sides for 40 seconds. The samples were kept in distilled water at 37°C for one week. Then, they were subjected to thermal cycles (5000 rpm) between 5°C and 55°C with a dwell time of 30 seconds and transfer time of 4 seconds. Finally, the samples were placed in self-hardening acrylic cylinders with a diameter of 1 cm and a height of 2 cm. The smooth surface of the specimens was outside the acrylic and parallel to the horizontal surface. The samples were then randomly divided (using the block randomization method) into 6 groups as follows:

Group 1: control group (aged composite + etched with phosphoric acid 37% [3M, Dental products, St. Paul]) etched to composite surface for 20 seconds, then rinsed for 20 seconds.

Group 2: aged composite + phosphoric acid etching + primer composite (GC, Tokyo, Japan) was placed on the surface of the composite as a thin layer using a microbrush and then cured for 20 seconds.

Group 3: (aged composite + etching with phosphoric acid + silane [Pulpdent, USA]) was applied a layer on the composite by a microbrush, and after 20 seconds of application, it was placed under air pressure for 5 seconds to evaporate the solvent.

Group 4: aged composite + etching with phosphoric acid + roughening with diamond bur.

Group 5: old composite + etching with phosphoric acid + roughening with diamond bur + primer composite.

Group 6: aged composite + etching with phosphoric acid + roughening with diamond bur + silane.

Standard metal brackets (Wisconsin Mini Master Series, American Orthodontics, Sheboygan, USA) with an average surface area of 10.88 mm were bonded to each of the prepared composite surfaces. Light-cured adhesive (bond XT 3M, Unitek, Monrovia, Calif, USA) was used to bond the brackets to the composite discs. For the bonding process, a thin layer of Transbond XT primer was rubbed on the prepared composite surfaces, but the curing operation was not performed at this stage. The brackets were bonded to the center of the composite discs using adhesive composite resin. The excess adhesive was removed with a small scaler. Polymerization was performed for 20 seconds on both sides of the composite discs. All parts were kept in distilled water at 37°C for 1 week and then subjected to 1000 thermal cycles between 5°C and 55°C with a dwell time of 30 seconds and a transfer time of 4 seconds. The shear bond strength test was performed using a Hounsfield universal testing machine. To test the shear bond strength, the specimens were subjected to occlusal stress at a rate of 1 mm/min. The maximum force required for drilling was calculated in Newton and converted to MPa by Newton's formula.

For descriptive statistics of quantitative variables, mean ± standard deviation (SD) was used, and for qualitative variables, frequency (percent), graphs, and statistical tables were used. The least significant difference (LSD) and one-way ANOVA were used to analyze the data. In all statistical tests, a *P* value of less than 0.05 was considered to be significant. The obtained data were recorded and transferred to SPSS.

Results

The means shear bond strength of orthodontic brackets in the groups are shown in Table 1. The highest and the lowest shear bond strength values were found in the fourth and control groups, respectively, indicating a significant difference across all groups ($P = 0.001$). In this regard, the results of the LSD test also showed that the mean shear bond strength of orthodontic brackets in the control group was significantly lower than that observed in other experimental groups, but without significant difference across the pointed groups ($P = 0.001$) (Table 2).

Discussion

In the present study, the aging process of the composite was carried out in a water chamber for 1 week and the thermal cycling was performed between 5°C and 55°C at 5000 rpm. The thermal cycle with the release of water accelerates the aging process of the composites. Different time and temperature conditions have been used to evaluate these parameters in different studies; however, all previous studies have reported that thermal cycling has a negative effect on shear bond strength (28 ,29). Some previous studies that have evaluated the shear bond strength of orthodontic brackets in composites have not performed the aging process of composites before orthodontic brackets are glued (30). The shear bond strength reported in some studies was very high, which can be attributed to the use of new composites. In the study conducted by Bayram et al (6), the shear bond strength between old composites and metal orthodontic brackets using two surface roughening methods was evaluated and it was revealed that milling abrasion has a much higher strength than aluminum oxide particles. The studies by Tayebi et al (31) and Demirtas et al (25) also confirmed higher efficiency of milling in surface roughness compared to abrasives; however, it should be noted that milling to expose the surface roughness, exposes the composite fillers on the tooth surface and reduces the restorative beauty, which is not desirable in the anterior teeth. On the other hand, to prevent restoration failure, resin residues must remain on the tooth surface after detachment of the brackets (32); however, removing resin residues after detachment of the brackets is costly, difficult, and time-consuming. Most orthodontic brackets are currently made of stainless steel. These brackets are resistant to masticatory forces and at the same time can maintain their flexibility. They also easily adapt to the shape and contour of the tooth. Given that composite resins do not have the ability to chemically bond to stainless steel, other mechanisms such as the use of bondings to improve the adhesion between the two

Table 1. The Mean Shear Bond Strength of Orthodontic Brackets in the Groups

Group	Minimum	Maximum	Mean	SD
1	3.01	7.58	5.86	1.23
2	5.25	13.17	8.85	7.92
3	5.99	12.57	8.50	1.57
4	6.70	11.87	9.17	1.64
5	6.55	12.89	7.98	1.68
6	6.55	13.23	8.73	1.78

SD: Standard deviation.

Table 2. Results of LSD Post Hoc Test for Shear Bond Strength of Orthodontic Brackets Bonded to Old Composite in the Studied Groups

Group i	Group J	Mean Difference	Standard Error	*P* Value
Control				
	Second	-32.46	6.57	0.001
	Third	-28.67	6.57	0.001
	Fourth	-35.92	6.57	0.001
	Fifth	-23.02	6.57	0.001
	Sixth	-31.14	6.57	0.001
Second				
	Third	3.79	6.57	0.566
	Fourth	-3.45	6.57	0.604
	Fifth	9.44	6.57	0.155
	Sixth	1.32	6.57	0.841
Third				
	Fourth	-7.24	6.57	0.274
	Fifth	5.65	6.57	0.392
	Sixth	-2.47	6.57	0.708
Fourth				
	Fifth	12.90	6.57	0.053
	Sixth	4.77	6.57	0.472
Fifth				
	Sixth	-8.12	6.57	0.224

surfaces should be used (33).

Based on the results of the present study, the lowest shear bond strength value was observed in the first group (old composite plus etching with phosphoric acid). The study by Bayram et al (6) confirmed our findings and showed that phosphoric acid is incapable of forming a micromechanical bond between orthodontic brackets and composite restorations. The findings of the study by Lucena-Martín et al also confirm our findings (34). However, other studies have shown that the addition of 37% phosphoric acid improves bond strength between composite restorations and orthodontic brackets because it does not affect the mineral composition of the tooth and only cleans the surface of the composite (35).

The results of the present study showed that the addition of composite primer improves the shear bond strength of composite restorations bonded to orthodontic brackets. Tayebi et al (30) who compared the shear bond strength of orthodontic brackets to old composites using Transbond XT, Assure Plus, and composite primer reported that the shear bond strength of composite primers is much better than that of the others. The presence of monomer 10-methacryloyloxydecyl dihydrogen phosphate (MDP) in composite primers that form a chemical bond with dentin and also the presence of ethanol which increases the bond between composite and dentin are two of the advantages of using composite primers. In addition, the use of composite primers is less expensive than the other methods mentioned. For this reason, we also used composite primers to evaluate the shear bond strength in this study.

The present study also showed that the addition of silane improves the shear bond strength between orthodontic brackets and composite restorations. Kimyai et al showed that adding silane to 37% phosphoric acid increases bond strength between composite restorations; however, adding it when using primer composite and surface roughening does not affect the bond strength (36). A study by Brunharo et al (37) reported similar results. The study by Lucena-Martín et al (38) showed that the combination of silane and air abrasion has a cumulative effect on the shear bond strength between composite restorations and orthodontic brackets.

The results of this study also showed that surface roughness can increase the bond strength between old composite restorations and orthodontic brackets. Several methods have been proposed to increase the adhesion strength between two composites, among which is surface roughening that helps to increase the strength between the new composite and old composites (6). In this study, the shear bond strength between orthodontic metal brackets and old composites with or without surface roughness was evaluated using a composite primer and the use or non-use of silane. In this study, the shear bond strength of the first group (the control group) was lower than that of the other groups.

The results of the present study showed that the use of silane, composite primer, and roughening together does not significantly increase the bond strength; however, an increase in bond strength was observed in the use of each alone. The study by Tayebi et al (30) also showed that surface roughness increases the bond strength following the use of primer. Due to the fact that in surface roughening, composite fillers are exposed on the tooth surface, the contact surface between the composite fillers and silane is reduced which causes the shear bond strength to reduce. Additionally, the addition of silane did not increase the bond strength in the studied samples.

In laboratory studies including the present study, the intraoral environment cannot be completely simulated due to factors such as saliva composition, patient's behavior, and patient's habits that affect outcomes. Therefore, generalization of the results of a laboratory study to clinical situations should be done with caution. The aging of materials in the laboratory is done to better simulate clinical conditions. In addition, other factors such as the type of bonding material and mechanical and chemical surface properties can affect the shear bond strength between orthodontic brackets and old composites. Therefore, future studies should evaluate the effect of the composition of composites and bonding material on the shear bond strength of samples. Additionally, the effect of other surface preparation methods such as laser is one of the interesting topics in this field. Tensile bond strength and shear bond strength of fiberglass brackets can also be evaluated.

Conclusions

The results of this laboratory study showed that the shear bond strength between old composites and orthodontic brackets increases if surface roughening, composite primers, and silane are used. However, the cumulative effect of these materials on the increase of bond strength was not observed.

Authors' Contribution

MAMT: Study concept design, MHRN: data acquisition, AG: Data collection, ST: Revising,, Drafting and correspondance

Conflict of Interest Disclosures

The authors declare that they have no conflict of interests.

Ethical Statement

The present study has been reviewed and approved by Urmia University of medical science ethical committtе (code: IR.UMSU.REC.1398.473)

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