ORIGINAL ARTICLE

Shear bond strength of a self-etched resin cement to an indirect composite: Effect of different surface treatments

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Abstract

Objectives: The aim of this study was to compare the shear bond strength of resin cement (Rely X-U200) bonded to differently conditioned indirect composite samples.

Materials and Methods: Sixty-six composite resin specimens (5 mm in diameter and 3 mm in thickness) were prepared with an indirect composite resin (Grandia) and randomly divided into six groups. Surfaces of the samples were treated with one of the following treatments; %37 phosphoric acid etching, sandblasting, 1,5 W, 2 W and 3 W erbium, chromium: Yttrium-scandium-gallium-garnet laser application. An untreated group was used as a control. In each group surface of the sample was analyzed with scanning electron microscopy. The remaining samples ($n = 60$) were built up with a self-adhesive resin cement (Rely X-U200) 3 mm in diameter and 2 mm height. After 24 h water storage at 37°C, the prepared specimens were submitted to shear bond strength test. One-way analysis of variance was used to analyze the bond strength values of different groups.

Results: Highest shear bond strength values were observed in sandblasting group however there were not statistical difference among the tested surface treatment methods.

conclusion: In Shear bond strength of resin, cement was independent of the surface conditioning methods applied on tested indirect resin composite.

Key words: Composite resins, dental bonding, resin cements, surface properties

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Introduction

Indirect composites are used in an attempt to overcome some shortcomings of direct composites such as high polymerization shrinkage, gap formation, poor wear resistance in contact area, color instability, difficulty in generating proximal contour and contact, lack of marginal integrity and postoperative sensitivity.[1-5] Material manipulation out of the mouth allows better proximal contacts, morphology, and adjustment of the occlusal surface. Ekstraoral polymerization allows higher conversion rate, thus enhancing the composite mechanical properties. Moreover, polymerization shrinkage takes place outside the mouth, and this limits the shrinkage to that of the thin luting cement layer.[6]

Resin bonding is a crucial step in the process of placing indirect composites and critical for the longevity of restoration.[7] Successful cementation increases the retention and the fracture resistance of the tooth and

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the restoration, while also reducing the incidence of micro-leakage.[8,9]

Increasing the roughness of indirect composite resins through various surface treatments may provide a better mechanical interlocking and stronger chemical bond to the cement.[7] The internal surface of indirect restorations can be treated with sandblasting, acid etching or laser applications.

Erbium, chromium: Yttrium-scandium-gallium-garnet (Er, Cr: YSGG) laser emits energy at a wavelength of 2780 nm, which coincides with the absorption peak of water and is popularly being used in conservative dentistry, especially for cavity preparation.[10] Er, Cr: YSGG laser is capable of producing surface roughness comparable to that produced by acid etching of enamel and dentin surfaces.[11]

Until date, there are only a few studies present about the etching effect of Er, Cr: YSGG laser on indirect composite resins[12] and adhesion of self-adhesive resin cements to indirect composites.[13-16]

This research was designed to identify ideal surface treatment procedures for indirect composites including; phosphoric acid etch, sandblasting and different parameters of Er, Cr: YSGG laser applications. The null hypothesis was that; different surface applications would not improve the shear bond strength of self-etched resin cement to an indirect composite.

Materials and Methods

Figure 1 shows the flow chart of the study. 66 cylindrical shaped, DA2 shade indirect composite resin samples were prepared with an indirect composite resin (Grandia; GC Dental Products Co., Tokyo, Japan). Table 1 demonstrates material details. Restorative material was inserted into a polytetrafiuoroethylene mold (5 mm in diameter and 3 mm in height) over a transparent polyethylene terephthalate strip (Mylar, Henry Schein, Melville, NY, USA) as an increment of 2 mm and light-cured for 10 s using a light-curing unit (Elipar Free Light S10, 3M ESPE, St. Paul, MN, USA). The last increment of composite was confined with the Mylar strip and light-cured for 10 s.

To complete the polymerization process; samples were removed from the molds and placed into a curing unit (Labolight LV-III; GC Dental Products Co., Tokyo, Japan) for 3 min according to the manufacturer's instructions. Subsequently, samples were stored in distilled water for 24 h at 37°C. Indirect composite samples divided into six groups ($n = 11$).

- Control group: No roughening surface treatment was carried out
- Phosphoric acid group: Samples were etched with 37% phosphoric acid (Vococid, Voco, GmbH, Cuxhaven, Germany) for 20 s, rinsed and air dried
- Sandblasting group: Surfaces of the indirect composite resin samples were roughened by sandblasting (Ney, Blastmate II, Yucaipa, CA, USA) aluminum oxide particles of 120 μ with 10 mm distance and for 20 s, samples were then cleaned in an ultrasonic device for 2 min
- 1,5 W (Er, Cr: YSGG) group: Samples were irradiated with Er, Cr: YSGG laser (Waterlase MD, Biolase Technology, Inc., Irvine, CA) with the laser beam

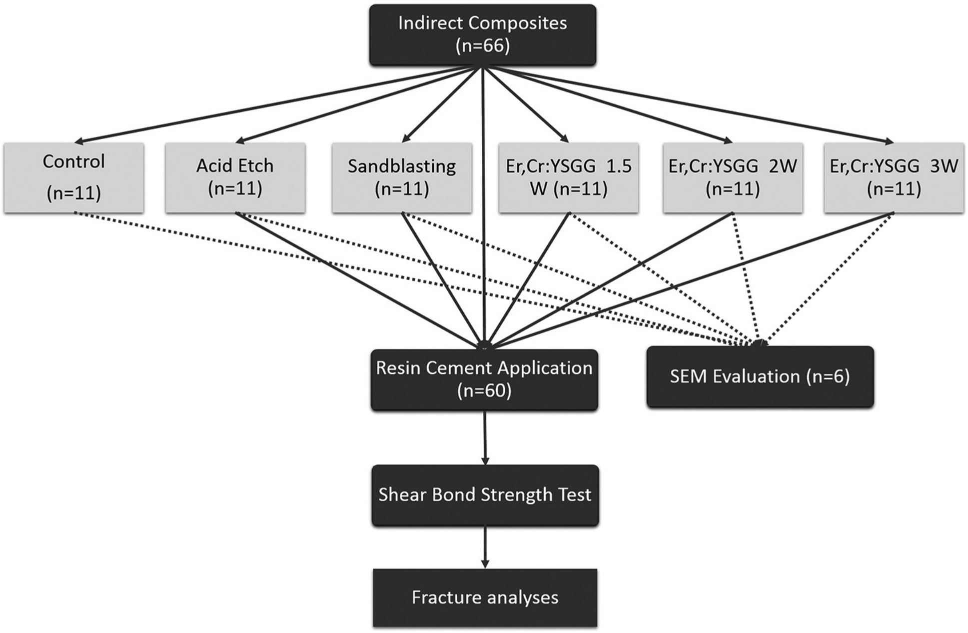

Figure 1: Representing the study design

parameters of 10 Hz, 1.5 W, 150 mJ, at a distance of 10 mm from the surface for 20 s at 15% air level and 10% water level

- 2 W Er, Cr: YSGG group: In the fifth group surface treatment was done with a Er, Cr: YSGG laser parameters of 10 Hz, 2W, 200 mJ, at a distance of 10 mm from the surface for 20 s at 15% air level and 10% water level
- 3 W Er, Cr: YSGG group: Er, Cr: YSGG laser parameters was 10 Hz, 3W, 300 mJ, at a distance of 10 mm from the surface for 20 s at 15% air level and 10% water level.

In each group one sample was randomly selected for scanning electron microscopy (SEM) evaluation in order to examine the surface properties.

Scanning electron microscopy analysis

After surface treatments one sample in each group were viewed and photographed using a SEM (JSM 6060LV; Jeol, Tokyo, Japan). Samples were sputter coated with gold, vacuum-packed in argon for 2 min (Polaron Range SC 7620; Quorum Technology, Newhaven, UK). Images were taken at magnifications of ×1000 for determining the nature of the bond failure and 20 kV accelerating voltage, 80 μA beam current.

Cementation procedure

After surface preparations, specimens were placed into another cylindrical Teflon mold (3 mm diameter, 2 mm height) and resin cement (Rely X-U200; 3M ESPE, St. Paul, MN, USA), was applied on composite specimens according to the manufacturer's instructions. Material details are shown in Table 1. After cementation samples were stored in distilled water at 37°C for 24 h and embedded into acrylic resins by using a silicon mold (14 mm diameter, 20 mm height).

Shear bond strength test

Shear bond strength test were conducted by using a universal testing device (Lloyd LF Plus; Ametek Inc., Lloyd Instruments, Leicester, UK). Samples subjected to a shear force at a crosshead speed of 1 mm/min until failure occurred. To assess the type of failure fractured specimens were observed under a stereomicroscope (Stemi DV4; Gottingen, Germany) at ×32 magnification. Three types of failure were defined; adhesive failure, in which resin cement completely separated from the composite surface, cohesive failure, in which resin cement completely fractured, and mixed failure in which both adhesive and cohesive failure were jointly observed.

Statistics

To evaluate the shear bond data distribution, Kolmogorov-Smirnov and Shapiro-Wilk test was used. Considering the normal distribution of the data in all groups, one-way analysis of variance (ANOVA) test was performed ($\alpha = 5\%$). Statistical analyses were conducted with SPSS for Windows, Version 16 (SPSS, Inc., Chicago, IL, USA). Power analysis was performed using the software package G-Power (G-Power 3.1.7, Franz Faul, University of Kiel, Kiel, Germany). The level of significance was defined as 0.05.

Results

Sample size of this study has a high statistical power of 95%. Figure 2 represents the mean bond strengths of tested groups with standard deviations. The results of one-way ANOVA didn't show a significant difference among the bond strengths of different surface treatment methods ($P < 0.05$). Maximum shear bond strengths were observed in the

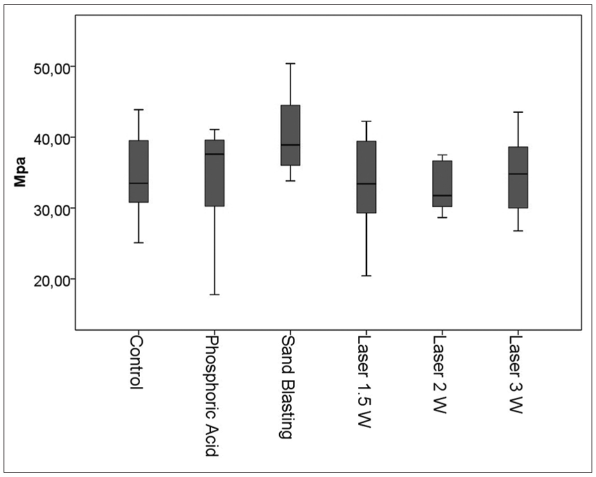

Figure 2: The means and the standard deviations of the shear bond strength. There was no statistical difference between surface applications

Table 1: Material details

Material	Manufacturer	Matrix	LOT number
Gradia (DA2 Shade)	GC Corp., Tokyo, Japan	Resin: UDMA, EDMA Fller: Aluminoborosilicate and silica	0710022
Rely X U200	3M ESPE, St. Paul, MN, USA	Silane treated glass powder, substituted dimethacrylate 1-benzyl-5-phenyl-barbic-acid, calcium salt, silane treated silica, sodium p-toluenesulfinate, 1,12-dodecane dimethycrylate calcium hydroxide methacrylated aliphatic amine methacrylated aliphatic amine titanium dioxide	20060822

UDMA=Urethane dimethacrylate; EDMA=Ethyleneglycol dimethacrylate

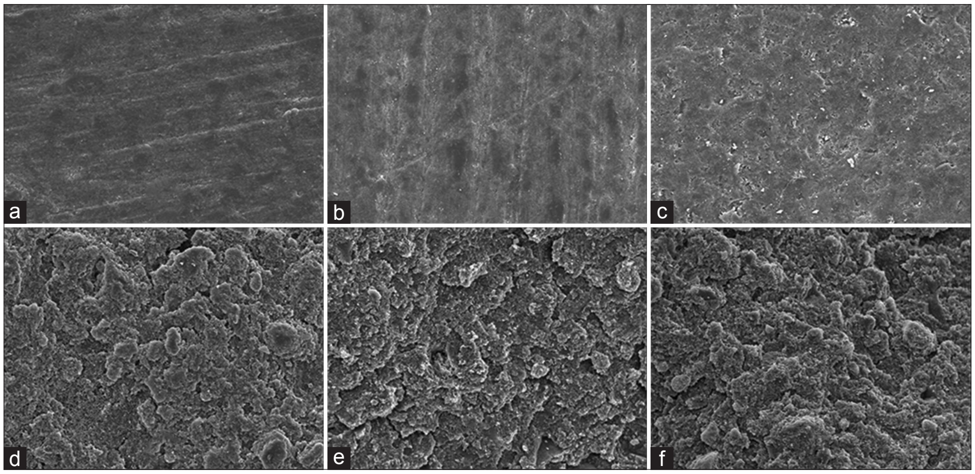

Figure 3: Scanning electron microscopy photomicrographs (×1000) of indirect composite samples after surface treatments. (a) Control group, (b) 37% phosphoric acid group, (c) Sandblasting group, (d) 1,5 W erbium, chromium: Yttrium-scandium-gallium-garnet (Er,Cr:YSGG) group, (e) 2 W Er,Cr:YSGG group, (f) 3 W Er,Cr:YSGG group

sand blasting group (40.2 ± 5.8 MPa) while 2 W Er, Cr: YSGG group have a minimum shear bond strength values (32.7 ± 3.4 MPa).

When the failure types were observed, it was noted that all groups except sandblasting group adhesive failure was predominant followed by cohesive failures. In sandblasted samples cohesive and mixed failures were overriding.

Figure 3 shows SEM micrographs of indirect resin composites surfaces after different surface treatment methods. Smooth and homogenous surfaces were observed in control and sandblasting groups. Sandblasting and Er, Cr: YSGG laser groups have a relatively irregular rough surface when compared with control. Surface of Er, Cr: YSGG laser group were very rough and irregular then other groups.

Discussion

Indirect composites polymerized in laboratory have been used to enhance the degree of conversion, thus improving the mechanical properties.[17] Conditioning procedures to create retentions on composites remove the oxygen inhibited superficial layer of composite monomers and increased the exposure of fillers.[18]

Surface treatment prior to the cementation process increases the surface roughness and provides better micromechanical interlock of the luting agent to the restorative material.[19,20] Resin-based adhesive cements are widely used for the cementation of indirect restorations. In order to simplify the multi-step cement application technique, novel self-adhesive resin cements include monomers that are capable of etching and bonding to the dental surface without an additional adhesive system. These cements simplify the bonding procedure and reduce cement film thickness and clinical time spent.[21]

Shear bond strength provides a common measurement of the maximum stress possible at the bonding interface.[22] Although various techniques have been proposed to improve the bond strength of indirect composites there seems to be no consensus in the literature for the ideal surface conditioning method.

In this study shear bond strength of a self-etched resin cement to an acid etched a sandblasted and 1.5 W, 2 W and 3 W Er, Cr: YSGG laser applied indirect composites resin was tested. Among these surface treatments, sandblasting produced the strongest bonds (40.2 ± 5.8 MPa) between indirect composite and resin cement. However there was no statistical difference among the tested groups. The hypothesis of null difference among tested groups was

Acid etching of composite samples with 37% phosphoric acid for 20 s did not enhance the bonding of resin cement. When SEM images were taken into account, there were no remarkable difference between the control group and acid etched group [Figure 3]. This is in accordance with some previous studies reporting acid etching is not sufficient to produce improved bond strengths to indirect composite resin surfaces.[15,23]

Abrasion with aluminum oxide particles is a common method for achieving strong adhesion between adhesive resins and indirect restorations. In this study, highest shear bond strength values (40.2 ± 5.8 MPa) were recorded in sand blasting group. SEM images [Figure 2] showed that sand blasting slightly roughened the composite resin surface when compared with the control group, but there were no deep irregularities.

Laser application is one of the methods of surface treatment used for improving micromechanical retention and bond strength of resin cement to indirect restorations.[18,24,25]

Use of Er, Cr: YSGG laser has been increasing in the field of dentistry especially for removing dental caries with minimal damage to tooth structure.[10,26,27] The absorption of Er, Cr: YSGG (2.78 μm) laser energy by water is believed to be partially responsible for its hard tissue-cutting effect. In this study, we can speculate that water absorbed by the indirect composite is the actual the absorber of the erbium laser radiation and thus the mediator of the thermo mechanical ablation process.[25,28] The absorption of photon energy causes vaporization, resulting in macroscopic and microscopic irregularities through micro explosions of the material surface.[22]

Kursoglu *et al*. reported that Er, Cr: YSGG laser irradiation at 1.5 W and 2.5 W increased shear bond strengths between ceramic and resin cement compared with untreated ceramic surfaces.[25] Kimyai *et al*. investigated the effect of three mechanical surface treatments including diamond bur, air abrasion and 2 W Er, Cr: YSGG laser application on the repair bond strength of a laboratory composite and reported that Er, Cr: YSGG laser was confirmed to be as effective as air-abrasion for laboratory composite repair.[12]

The effect of increasing Er, Cr: YSGG laser irradiations (1.5 W, 2 W and 3 W) on an indirect composite resin was tested in this study. SEM images [Figure 3] showed that laser applications caused very rough and irregular surfaces when compared with the control group. As a result of increased surface roughness it could be expected that shear bond strength of resin cement could also be raised with the extra penetration to the irregular surfaces however there were no statistical difference among shear bond strength of laser applied groups and other tested groups. This could be explained with the over destruction and weakening of the surface. This result agreed with the previous study by Cho *et al*. who evaluated various surface treatments on repaired shear bond strength between aged and new resin composites and reported that although the surface roughness values of the 4 W Er, Cr: YSGG laser irradiated group was highest; there was no significant difference in shear bond strength between the Er, Cr: YSGG laser group and the control group specimens.[22]

In sandblasting group, cohesive failures were observed predominantly followed by mixed failures, while in the other groups most failures were adhesive followed by cohesive failures. It can be assumed that sandblasting protocol is more appropriate to bear the occlusal loads.[12]

Only one type of laser with three power settings and one type of indirect composite resin was tested in this study since the components of the resin-based indirect composites may vary, different composites with different formulas could affect the ablation rate. Therefore, assessment of other composites and laser types and energy parameters are needed.

Conclusion

With the limitations of this study, we can conclude that the shear bond strength between indirect composite resin and new generation self-adhesive resin cement is independent of the surface roughening applications tested here. Sand blasting, phosphoric acid etching and Er, Cr: YSGG laser applications did not improve the shear bond of self-etching adhesive resin cement strength statistically.

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