

Comparison of the Effect of Three methods of Porcelain Surface Treatment on Shear Bond Strength of Composite to Porcelain

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Abstract

Background and Aim: Several methods are available for intraoral repair of chipped porcelain restorations by composite resin. Also, there is still controversy regarding the best method of porcelain repair in terms of bond strength and cost effectiveness. This study aimed to compare three methods of porcelain surface treatment on shear bond strength (SBS) of composite to porcelain.

Materials and Methods: This in vitro, experimental study was conducted on 30 porcelain blocks with a metal base in three groups. In group 1, porcelain surface was etched with hydrofluoric (HF) acid and silanized. After the application of bonding agent, several composite increments with 2mm thickness were applied on the porcelain surface. In group 2, porcelain surface was sandblasted with 50 μ aluminum oxide particles, etched and silanized. In group 3, grooves with 2mm length and 0.5 mm depth were created on the porcelain surface. The surface was then etched and silanized. Bonding agent and composite were then applied. The samples were then mounted in acrylic resin, stored in water for one week and subjected to thermocycling. The SBS was then measured using a universal testing machine. The SBS data were compared among the three groups using one-way ANOVA.

Results: The mean SBS was 9.13 \pm 6.09, 12.71 \pm 9.82 and 11.44 \pm 7.37 MPa in groups 1-3, respectively. No significant difference in bond strength was noted among the three groups ($P>0.05$).

Conclusion: No significant difference exists among the three surface treatment methods evaluated in this study in terms of SBS of composite to porcelain.

Key Words: Dental Porcelain, Shear Strength, Composite Resins

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Introduction

Ceramics have long been used for esthetic dental restorations. All-ceramic and metal-ceramic restorations are used for severely damaged teeth aiming to provide strength and optimal esthetics. Despite the brittleness of ceramics in case of

trauma or fatigue, they provide excellent esthetics [1]. However, fracture and chipping of porcelain restorations cause patient dissatisfaction and are problematic for dentists [2]. The prevalence of porcelain fracture has reported to be 2.3% to 8% [3]. Porcelain fracture is often multifactorial [4-6],

and insufficient bond strength of porcelain is one reason for porcelain fracture [7,8]. Bond to porcelain has been an interesting topic of research [9] and depends on the type of porcelain surface treatment [10]. Since removal of a fractured or chipped porcelain restoration is difficult in the oral cavity, intraoral repair of these restorations is desirable and eliminates the need for replacement of the entire crown and saves time and cost. Therefore, it is desirable for both patient and clinician. For this purpose, the safest and most efficient technique of repair must be chosen.

The primary repair systems were based on mechanical retention and use of organosilane coupling agents. Several surface preparation methods such as surface roughening, abrasion by aluminum oxide particles and etching with HF or phosphoric acid have been assessed in vitro to enhance the bond of composite resin to porcelain [10-12]. Acid etching is one method to eliminate the smear layer and debris from the porcelain surface and enable micromechanical retention of resin. Silane coupling agent is also used to increase the bond of composite resin to ceramics [13,14]. Sandblasting is another modality to increase the bonding surface area and surface roughness and create undercuts on the ceramic surface [15,16]. Silane was introduced to create adhesion in dentistry. It creates an interface between a mineral substrate such as glass, metal or a mineral compound and an organic substrate such as an organic polymer in order to bond dissimilar materials to each other. Liu et al. [11] evaluated porcelain repair with hydrophilic resin following sandblasting, surface roughening, etching with phosphoric acid and a combination of all. They concluded that the most effective method of surface preparation was surface roughening and acid etching; however, the differences were not statistically significant. The new generation of porcelain systems include a wide range of chemical materials and chemical methods for porcelain surface preparation. Surface preparation plays an important role in enhancing the bond of composite to porcelain and success of repair [17]. Several surface preparation methods have been evaluated to enhance the bond of resin to porcelain [18]. Sorensen et al. [19] measured the shear bond strength of composite to porcelain using different

method. They show that both methods have similar efficacy for bond of composite to porcelain.

However, the question remains regarding the superiority of one method over the other in terms of bond strength. The aim of this study was to assess the effects of three different porcelain surface preparation methods on SBS of composite to porcelain.

Materials and Methods

In this in vitro experimental study, 30 porcelain blocks (In-Ceram; Ivoclar Vivadent, Schaan, Liechtenstein) with a metal base were fabricated and divided into three groups of 10. First, a metal base was fabricated of nickel chromium with a thickness of 1 mm and diameter of 3 mm. Some retentive porosities were also created in the metal base for later mounting in acrylic resin. Feldspathic porcelain (Ivoclar Vivadent, Schaan, Liechtenstein) was added on the metal base up to 1.5 mm thickness. A layer of wax was also added on the metal base with 1.5 mm thickness. A putty impression was made to serve as an index for standardization of porcelain thickness. The surface of porcelain was then polished with aluminum oxide bur and low speed rotary instruments. Next, Tetric-Ceram composite (Ivoclar Vivadent, Schaan, Liechtenstein) was applied on the porcelain surface with 2 mm thickness. The other side of porcelain was in contact with metal. The method of standardization of composite thickness in all samples was similar to addition of porcelain to metal base. Before addition of composite to porcelain, the samples were divided into three groups of 10.

Group 1: The porcelain surface was etched with 11% HF acid (Kimia, Tehran, Iran) for 60 seconds, thoroughly rinse with water and dried with air spray. After removal of debris, silane (Monobond-S; Ivoclar Vivadent, Schaan, Liechtenstein) was applied on the surface with a micro-brush. The porcelain surface was allowed to dry for 60 seconds. Next, the surface of samples was dried with air spray without moisture as recommended by the manufacturer and the Excite bonding agent (Ivoclar Vivadent, Schaan, Liechtenstein) was applied on the surface and light cured by a light curing unit (Coltene, Langenau, Germany) with a light intensity of 400 mW/cm² for 20 seconds.

Repair composite (Tetric-Ceram, Ivoclar Vivadent, Schaan, Liechtenstein) was incrementally applied on the porcelain surface and light cured for 40 seconds [7].

Group two: The porcelain surface was sandblasted with 50 μ aluminum oxide particles. The sandblasted surfaces were etched with 11% HF acid for 60 seconds [7], rinsed and air dried. One layer of silane was then applied on the porcelain surface and after 60 seconds, it was dried with air spray. Excite bonding agent (Ivoclar Vivadent, Schaan, Liechtenstein) was then applied on the surface followed by composite application and light curing as in the previous group.

Group 3: Four parallel grooves, 0.5 mm in depth and 2mm in length, were created on the porcelain surface using high-speed hand piece and fissure diamond bur with 1 mm diameter [7]. The dimensions of the grooves were measured by a Williams probe. As in the two previous groups, the porcelain surface was acid etched and silanized, and bonding agent and composite were applied.

Metal cylinders with retentive porosities were mounted in auto-polymerizing acrylic resin in rectangular molds measuring 3x3x5cm. First, wax cubes were fabricated with the afore-mentioned dimensions and filled with acrylic resin and then the samples were mounted in them. The mounting dimensions matched those of the holder of universal testing machine (Zwick, Leominster, UK) for SBS testing. The entire metal base was mounted in the acrylic resin to the level of porcelain. The samples were immersed in water at room temperature for one week and were then subjected to 1000 thermal cycles.

The samples were transferred to the universal testing machine. Load was applied by a chisel-shaped rod with a crosshead speed of 0.5 mm/minute at 90° angle and continued until fracture or debonding. Load was applied to the porcelain-composite interface. The machine was connected to a computer, which drew a graph of load application until fracture. In assessment of the mode of failure, cohesive failure was defined as fracture within the porcelain while adhesive failure was defined as fracture at the interface of composite and porcelain. The bond strength values

were compared among the three groups using ANOVA.

Results

The required load for fracture of the samples ranged from 3.61 to 18.59 MPa in group 1 (the mean value was 9.13 MPa). In group 2, the SBS ranged from 4.25 to 23.46 MPa (with a mean value of 12.71 MPa). In group 3, the SBS ranged from 4.93 to 16.38 MPa with a mean value of 11.44 MPa (Table 1). Regarding the mode of failure in group 1, out of 10 samples, 9 (90%) showed adhesive failure and one sample (10%) showed cohesive failure. In group 2, out of 10 samples, 9 (90%) showed cohesive failure and one sample (10%) showed adhesive failure. In group 3, out of 10 samples, 6 (60%) showed adhesive failure and 4 (40%) showed cohesive failure. ANOVA found no significant difference among the three groups in terms of SBS between the composite and porcelain ($P=0.27$, Table 2).

Table 1. Shear bond strength (MPa) values in the three groups

Group	Mean	Standard deviation
1	9.13	9.6
2	12.91	9.82
3	11.44	7.37

Table 2. Mode of failure

Group	Cohesive(%)	Adhesive(%)
1	10	90
2	90	10
3	40	60

Discussion

Methods for intraoral repair of chipped porcelain by composite resin have been the topic of many previous studies. The clinical success of porcelain repair systems almost entirely depends on the bond strength of porcelain to composite [17]. This bond can be achieved via mechanical and chemical methods. These methods should not only provide adequate bond strength, but also should be fast and

cost-effective [17]. Different methods have been suggested for preparation of porcelain surface for bond to composite. Based on the results of our study, all three methods of porcelain surface preparation were equally effective for bond of composite to porcelain. These methods included chemical bond obtained by using silane along with acid etching (micromechanical bond), chemical bond (silane) obtained by acid etching and sandblasting (micromechanical bond) and chemical bond obtained via acid etching and mechanical bond by creation of retentive grooves. Accordingly, it appears that none of the tested methods had any superiority over the others in bond of porcelain to composite. In total, the hypothesis of equal efficacy of different preparation methods for SBS of composite to porcelain was accepted.

Previous studies [20-22] used sandblasting, HF acid etching and a combination of both and showed that the combination of both methods was more effective for increasing the bond strength between composite and porcelain. Similarly, our study showed that creating mechanical retention by acid etching and sandblasting resulted in higher bond strength, although it was not statistically significant. Therefore, this method had no superiority over other mechanical methods such as groove creation.

Liu et al, [11] in 2014 compared sandblasting, surface roughening by diamond bur, 9.6% HF acid etching and a combination of scratching and acid etching and concluded that combination of acid etching and scratching the surface was superior than other methods but the differences were not statistically significant. In our study, creation of mechanical retention by using a combination of acid etching and grooving by diamond bur yielded a higher bond strength compared to acid etching alone but this difference was not statistically significant. In our study, some grooves were created in the porcelain surface with specific dimensions while Liu et al, [11] in 2014 only roughened the porcelain surface by bur.

On the other hand, Shahverdi et al. [21] indicated that sandblasting + acid etching + silane was the most effective surface preparation method while Liu et al. [11] reported that roughening the surface by bur plus acid etching was more effective than

sandblasting plus acid etching. Thurmond et al. [7] compared the efficacy of HF acid etching, sandblasting and roughening of porcelain surface by bur and reported that combination of acid etching and sandblasting was the most effective method and created the highest bond strength. Similarly, creation of mechanical retention by a combination of acid etching and sandblasting resulted in a higher bond strength but this difference was not statistically significant. Kussano et al. [23] roughened the surface combined with acid etching and used both HF and phosphoric acid. They indicated that both acids had the same efficacy for this purpose and the effect of surface roughening was less than that of acid etching. According to Canay et al, [24] if loads applied to samples are equal or less than 13 MPa, the cohesive mode of failure converts to adhesive failure. The same results were obtained in our study and by an increase in load, mode of failure changed from adhesive to cohesive. Although combination of acid etching with 11% HF acid and sandblasting by aluminum oxide particles had no superiority over acid etching with 11% HF acid alone (statistically) or grooving by diamond bur, it should be noted that in our study, the ratio of cohesive failures to adhesive failures in the sandblasting plus acid etching group was 9 to 1. This ratio was 6 to 4 in surface grooving plus acid etching group and 1 to 9 in acid etching group. The mean SBS in group 2 was higher than that in group 1 by about 3.5 MPa.

The reason for use of sandblasting plus acid etching with 11% HF acid in our study was because this method is known as an ideal method to increase the bond strength of resin to porcelain [25]. However, in our study this method had no significant difference with other modalities. Our results showed that grooving of the porcelain surface can also be used as an effective method to enhance the bond of porcelain to composite. On the other hand, sandblasting of the chipped porcelain requires expensive equipment and is also time-consuming; therefore, it is not cost-effective for dentists and has no superiority over simpler methods such as acid etching and creation of mechanical retention by bur.

Shear and tensile bond strength tests are routinely performed. Torsional tests are also employed in

some cases. Shear and tensile tests are applicable and reliable for assessment of bond strength. However, in order to accurately calculate the interfacial failure stress, these tests should be designed in such a way that stress is uniformly distributed at the interface.

Conclusion

No significant difference was noted in bond strength of composite to porcelain in acid etching, acid etching plus grooving and acid etching plus sandblasting. However, since the latter method was slightly superior, use of this simple technique is recommended to enhance the bond strength of composite to porcelain.

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