Original Article

Comparison of Shear Bond Strength between Composite Resin and Porcelain Using Different Bonding Systems

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Abstract:

Statement of Problem: Ceramics as in ceramo-metallic and all ceramic tooth restorations have grown popular owing to their high tissue compatibility and esthetic advantages. Such restorations have the capability to deliver valuable services over a long period of time; however, failures under intraoral conditions are not unanticipated.

Purpose: The purpose of this in-vitro study was to investigate the shear bond strength of composite resin to porcelain using different bonding system materials.

Materials and Methods: In this experimental study forty porcelain blocks were prepared and randomly divided into four equal groups. The porcelain surfaces were then etched with HF for 2 minutes, washed with water for 2 minutes and treated with a silane layer. The silane treated porcelain surfaces were left for one minute and then the specimens were bonded to composite resin as follow:

Group 1 (control group), hybrid composite Z100 was applied and light cured from four directions for 20 seconds. Group 2, flowable composite was applied and light cured for 20 seconds. Group 3, unfilled resin was used and photo cured for 20 seconds. Group 4, (Dentin bonding agent) adhesive resin was used followed by 20 seconds photo curing.

Hybrid composite resin Z100 was subsequently applied on all porcelain surfaces of groups 2, 3 and 4, and light cured for 20 seconds from four directions. Specimens were then subjected to thermocycling 1000 times. Shear bond strength was determined by a Universal testing machine. The data obtained was subjected to a one-way ANOVA test.

Results: The results indicate that there is a statistically significant difference between adhesive group and the other three groups of hybrid, flowable and unfilled resin ($P<0.05$).

Conclusion: The results from this study showed that the shear bond strength of composite resin to porcelain was significantly higher for porcelain bonded surfaces using a dentin bonding agent than that of other materials tested.

Key words: Ceramic; Dentin bonding, Silane; Composite resin; Shear bond strength; Porcelain

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INTRODUCTION

Dental porcelains must possess certain special properties in order to be an appropriate surrogate for destroyed or missing natural tooth structure. More importantly, they should provide sufficient strength and toughness; they should also prove to be morphologically adaptable.

Biocompatibility along with presenting the most appropriate shade and translucency similar to that of natural tooth are considered as other obligatory properties [1].

The most important characteristic feature of Porcelain is its strength and a lot of attempts

have recently been made to enhance porcelain structural durability.

Porcelain compressive strength is high and its elastic modulus is also relatively great, however, it's tensile and shear strengths are low contributing to the low flexibility [2]. The most important reason for ceramic failure is low tensile strength; where as in the alumina-reinforced ceramics, due to the high tensile strength, this problem has been resolved.

Crown failures may be attributed by the deepening of minute cracks that frequently appear on porcelain surface after firing. It should be mentioned that these cracks are formed due to thermal stresses, surface porosity, abrasion, moist etc. during the final crown glaze and can not be seen by naked eye[3].

Numerous techniques have been developed to strengthen porcelain such as treating porcelain surface with hydrofluoric acid. The great part of porcelain structure consists of silica; acidic ions penetrate into Si-O framework creating ten thousand (10,000) micro porosities/mm^2, in a honey comb appearance. Then, fluoride ions attack the Si-O framework resulting in the production of water soluble fluorosilicate [4].

Most investigators have emphasized on etching with HF as the most effective technique for porcelain surface treatment [5]. There is a difference between etchings of various ceramic restorations. Al_2O_3 as a ceramic is slightly etched [6]. The differences among ceramic materials depend highly on their composition and preparation techniques. Ceramics containing large quantities of alumina and zirconia are not efficiently etched with hydrofluoric acid [7].

For example, Incream of 85% alumina and Porcera crowns of 99% alumina are not properly etched with HF [8, 9].

SEM observations have revealed that porcelain feldspar etched with 10% hydrofluoric acid for 2.5 minutes creates a suitable substructure for composite to porcelain bond strength. Porcelain etched for 2.5 minutes would result in bond strength 2 to 3 times more than that of 20 minutes [10].

In a study on phosphoric acid effects was compared with HF, SEM examinations indicated that phosphoric acid does not exert any etching effect on porcelain [11].

Silane is considered as the most appropriate material to promote composite to porcelain bond strength. Applying a silane compound to surfaces to be repaired increases the bonding strength up to 25%, leading to a chemical bond [8,12].

Silane application on porcelain etched surfaces generates a strong and durable bond between a composite resin and a porcelain substrate [13].

The purpose of this study was to investigate the composite resin repair of porcelain using different bonding system materials.

MATERIALS AND METHODS

In this experimental study forty feldspar porcelain square blocks (Ceramco, Colorlogic, Veneer Porcelain, USA) were prepared and randomly divided into four equal groups. Following this, the ground porcelain surfaces were conditioned with 9.5% hydrofluoric acid for two minutes, washed with water and dried with compressed air for 30 seconds.

Then, a silane layer (Scotch Bond Ceramic Primer, 3M ESPE dental products, USA) was applied to the surfaces to be repaired for one minute to react with the porcelain etched surfaces. In group 1, prepared molds (5mm in length and 3mm in diameter) were filled with Z100 hybrid composite (3M ESPE dental products) and were positioned against the porcelain surface. Photo-polymerization was achieved by directing the light toward the porcelain square surfaces for 20 seconds each.

In group 2, on conditioned porcelain blocks, a flowable composite resin layer (Filter Flow, 3M ESPE dental product) 0.5 mm in diameter was placed and light cured for 20 seconds. Then Z100 hybrid composite resin was used

and photo cured similar to the group one.
In group 3, a layer of unfilled resin (Colten, Switzerland) was applied to the conditioned porcelain surfaces with an applicator sponge, thinned with a gentle stream of forced air and polymerized by 20 seconds of light exposure. Composite resin, similar to the group 1, was then applied and light cured.
In group 4, on conditioned porcelain surfaces, adhesive resin (Scotch bond multi purpose, 3M ESPE dental products) was applied with an applicator sponge, thinned with a gentle stream of air and polymerized for 20 seconds. Then, likewise, hybrid composite was applied and photo cured.
In this study, composite resin, enamel and dentin bondings were light cured with Astralis soft start unit which initially emanates a low energy visible light to reduce polymerization shrinkage. Following stress releases, an increase in light energy will occur.
This was an in-vitro single blind type study meaning that the operator was informed of the specimens and the applied bonding systems, whereas, the evaluator was not furnished with such information. After polymerization of composite resin onto the porcelain surfaces, the specimens were placed in water for 24 hours, and then thermo cycled 1000 times between baths of water maintained at 5°C and 55°C, 30 seconds for each bath. Time interval between baths was 10 seconds.
All the specimens were placed in an universal testing machine (Instron, UK) operating at a crosshead speed of 5.0 mm/minute.
In order to measure the bond strength, expressed in MPa, the resultant force in Newton was divided into the cross-section of the bonded area.
Finally, stereomicroscopic observation, 40X magnifications, determined the mode of failures that occurred during debonding.
The data obtained was then subjected to a one-way ANOVA test. Tukey- HSD test was used to compute the differences between the test groups.

RESULTS

The shear bond strength data obtained for the four groups tested are shown in Table I. No statistically significant differences in the shear bond strength were found among the first, second and third group ($P>0.05$), whereas, the mean shear bond strength observed for adhesive group (19.77 MPa) was significantly higher than that of other three groups ($P<0.05$)
Stereomicroscopic observation revealed six cohesive and four adhesive failures in composite group, five cohesive and five adhesive failures in flowable composite group, eight cohesive and two adhesive failures in unfilled resin group and finally nine cohesive and one adhesive failure in adhesive group.

DISCUSSION

The results of this study suggest that shear bond strength of composite resin bonded to porcelain without using enamel or dentin bonding systems is acceptable since minimum required bond strength has been stated 13 MPa [14]. The present study and a study conducted by Appeldoom et al [15] both indicated that with shear bond strength less than 13 MPa, the cohesive failure pattern of composite resin changes into adhesive failure mode between composite resin and porcelain. In this study, the mean shear bond strength value among three groups with hydrophobic resin base was 14.5 MPa and that of adhesive group with high wettability, due to the presence of HEMA, was 19.77 MPa (Table I).
In one study, it was reported that the most observed failures in composite resin repairs of porcelain were of cohesive mode within the porcelain. Such failures could be related to flaws in the porcelain substrate that possibly occurs after the procedure [16]. Based on the stereomicroscopic examinations (40X magnifications) in this study, predominant mode of failure in adhesive resin group (4th

Table I: Descriptive statistics of minimum, maximum and mean shear bond strengths (in MPa) for groups tested

Sample	Minimum	Maximum	Mean (SD)
Group 1 (Composite)	12.44	17.41	14.80 (1.80)
Group 2 (Flowable composite)	11.94	16.5	14.68 (1.34)
Group 3 (Unfilled resin)	8.71	18.66	14.17 (2.82)
Group 4 Dentin bonding (Adhesive resin)	16.17	24.88	19.77 (2.33)

group) was cohesive as only one adhesive failure occurred. In flowable composite group, half of the failures were cohesive and half were adhesive. Among unfilled resin group, two adhesive failures and eight cohesive ones were found. While in hybrid composite group, four adhesive and six cohesive failures were observed.

In a study by Eames et al and Kelsey et al all failures were attributed to adhesive mode [17, 18].

Gregory et al [19] reported that subjecting composite bonded to porcelain specimens to prolonged storage and thermocycling invariably leads to significant reduction in shear bond strength (25% to 69%). This loss of strength may be due to thermal stresses induced in porcelain leading to a progression of crack formation which is followed by an early cohesive failure within the porcelain.

Clinically this suggests that removal of questionable porcelain substrate prior to initiating a composite resin repair is critical and that this process should be as atraumatic as possible to minimize further crack formation within porcelain [16].

In previous studies, it was hypothesized that in composite resin repair of porcelain procedures, surface treatment seemed necessary only up to stage of silane application and using different kinds of enamel and dentin bonding materials. However these findings are in contradiction with the results obtained from the present study [4].

Some investigators believe that silane plays a relatively more important role than other agents. Culler et al [20] showed that different bonding strength value of various repair systems depend on silane activity and stability. Diax et al [21] reported that silane application alone without unfilled resin creates a high value bonding strength.

In this study regarding silane systems on hydrated and unhydrated surfaces, a statistically significant difference was observed for silane bonding strength values between dried and moist surfaces. In other words, silane provides a much higher bonding strength on dried porcelain surfaces comparing to moist ones confirming the results of the previous studies.

In the present study, prehydralyzed silane was applied seemingly to provide a more durable bond in comparison with silane that is hydrolyzed due to moisture absorption, heat treatment and acidic environment.

Conventional silane, such as methacryloxy propyltrimethoxy silane, change into active form following the absorption of three water molecules. The activated silane releases three methanol molecules that vaporize the water released in the reaction between silane and porcelain, whereas in prehydralyzed silane systems, methanol molecule is not released as a result of which water from silane and porcelain reaction would remain.

In conclusion, materials applied against porcelain surface are of high importance.

Hydrophilic materials containing HEMA, META or other monomers could increase bonding strength due to optimal resin penetration into porcelain.

In the present study, the applied adhesive Scotch bond system consisting of HEMA (30%-40% in volume) could produce more durable bond comparing to that of other systems with hydrophobic resin base [22].

Kelsey et al also indicates that an adhesive resin can be used, in all repair cases, following porcelain surface treatment prior to composite application. He reported the in-vitro shear bond strength as 12-25 MPa [18].

Craig states that a strong and durable bond, approximately 20-40 MPa, between a composite resin and a porcelain substrate is generated while using bonding systems although this claim violates the finding of previous studies [23].

CONCLUSION

The mean shear bond strengths after 24 hours of storage in water and thermocycling, in all four groups tested were higher than the minimum required bonding strength (13 MPa). The results from this study showed that the shear bond strength of composite resin to porcelain was significantly higher ($P<0.05$) for porcelain bonded surfaces using a dentin bonding agent than that of other materials tested.

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مقایسه استحکام باند برشی کامپوزیت به پرسلن با استفاده از سیستم‌های مختلف باندینگ

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چکیده

بیان مسأله: سرامیک‌ها چه به صورت رستوریشن‌های تمام سرامیکی و چه به صورت رستوریشن‌های فلز- سرامیک، به دلیل خصوصیات سازگاری بافتی و زیبایی مناسب، مورد اقبال روز افزون قرار گرفته‌اند. این رستوریشن‌ها طول عمر مفید بالایی دارند ولی عدم موفقیت آنها در بعضی موارد دور از ذهن نیست.

هدف: مطالعه حاضر با هدف مقایسه استحکام باند برشی کامپوزیت به پرسلن با استفاده از سیستم‌های باندینگ مختلف انجام شد.

روش تحقیق: در این مطالعه آزمایشگاهی، ۴۰ بلوک پرسلنی ساخته و به چهار گروه مساوی تقسیم شدند. سطح پرسلن‌ها با استفاده از HF به مدت ۲ دقیقه اچ شدند و پس از شستشو با آب به مدت ۲ دقیقه، یک لایه سایلن بر روی آنها زده شد. پس از ۱ دقیقه، سطح نمونه‌ها به یکی از روشهای زیر به رزین کامپوزیتی متصل گردید:

- در گروه ۱ (شاهد) کامپوزیت هیبرید Z100 بر روی سطح قرار داده شد و از هر چهار جهت به مدت ۲۰ ثانیه به آن نور تابانده شد.
- در گروه ۲، کامپوزیت flowable گذاشته شد و به مدت ۲۰ ثانیه تحت تابش نور قرار گرفت.
- در گروه ۳، رزین unfilled قرار داده شد و به مدت ۲۰ ثانیه تحت تابش نور قرار گرفت.
- در گروه ۴، adhesive resin (دنتین باندینگ) زده شد و به مدت ۲۰ ثانیه تحت تابش نور قرار گرفت.

سپس بر روی نمونه‌های گروههای ۲ تا ۴، کامپوزیت هیبرید Z100 گذاشته شد و به مدت ۲۰ ثانیه از چهار جهت با نور، کیور شد. در مرحله بعد تمام نمونه‌ها تحت ۱۰۰۰ دور ترموسایکلینگ قرار گرفتند. در نهایت استحکام برشی باند با استفاده از Universal Testing Machine اندازه‌گیری شد. داده‌ها با استفاده از آزمون تجزیه واریانس یک راهه مورد مقایسه قرار گرفتند.

یافته‌ها: بین گروه ادهزیو رزین و سه گروه دیگر اختلاف آماری معنی‌داری وجود داشت ($P< ۰/۰۵$).

نتیجه‌گیری: بر اساس نتایج این مطالعه، می‌توان گفت استحکام باند برشی کامپوزیت با پرسلن با استفاده از ادهزیو رزین به طور معنی‌داری بیش از سایر موارد مورد آزمایش بوده است.

واژه‌های کلیدی: سرامیک؛ دنتین باندینگ؛ سایلن؛کامپوزیت؛ استحکام باند برشی

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