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ORIGINAL ARTICLE

A Comparative Evaluation of Shear Bond Strength of Porcelain and Composite Using Different Bonding Agents – An *In Vitro* Study

Roseline Meshramkar, Suresh Sajjan

Objective: *The purpose of the present in vitro study is to compare and evaluate the shear bond strength of porcelain and composite using different bonding agents.* ***Materials and methods:*** *Sixty-three porcelain pellets were prepared and were divided into 9 groups. Three surface treatment and two bonding agents were evaluated. The surface treatment were: 1) sandblasting; 2) etching with 35% phosphoric acid; and 3) etching with 8% hydrofluoric acid. Applying bonding agents Scotch bond adhesive and clearfil liner bond 2V and combination of these treatments. Composite resin was condensed and light cured for 60 seconds on the porcelain specimens which were stored in distilled water at 37°C for 24 hours before mechanical testing.* ***Results:*** *The bond strength were significantly different according to ANOVA F-test ($F = 6.28$, $p < 0.01$) and Duncan's Multiple Range Test. Eight percent hydrofluoric acid showed higher bond strength when compared to 35% phosphoric acid etching and sandblasting by 50 micron aluminum oxide. Highest bond strength was observed with hydrofluoric acid + clearfil.* ***Conclusion:*** *Etching with 8% hydrofluoric acid + clearfil liner bond showed higher bond strength when compared to hydrofluoric acid alone. This is indicative that effect of silane and etching can be use to improve mechanico chemical bonding. Among bonding agents used clearfil liner showed higher bond strength when compared to scotch bond adhesive.*

Keywords: Porcelain repair, Bond strength, Composite, Bonding agents, Surface treatment, Fractured porcelain, Acid etching, Sandblasting

Introduction

Ceramic materials are popularly used in the present day practice either in the form of all ceramic or as PFM restoration [1]. These materials provide an excellent restorative service. However being brittle material ceramic failures do occur. Fracture of ceramic and ceramometal restorations are frustrating but not an uncommon problem in restorative dentistry [2].

Fracture of porcelain may occur for numerous reasons such as poor metal framework design, faulty technique in fabrication of the porcelain, trauma, occlusal impact, fatigue, micro defects within the material, contamination and premature occlusion [3, 4].

Replacement of failed restoration is not a most practical solution because of economic reason and complex nature of the restoration [5]. Various methods have been advocated to repair fractured porcelain with composite resin [6]. One of the major problems in repairing porcelain is bonding the repair composite to fractured surface. The bond strength of composite is also influenced by the bonding agents and

R. Meshramkar[1] ✉ • S. Sajjan[2]
[1]Department of Prosthodontics,
SDM College of Dental Sciences and Hospital,
Sattur, Dharwad – 580009
[2]Department of Prosthodontics,
Vishnu Dental College,
Bhimavaram – 534202

e-mail: roselinemeshramkar@yahoo.co.in

the type of composite resin used for repair [7, 8]. Dental adhesive systems were initially introduced for bonding composite to mineralized tooth structure [9]. The newer generation of adhesive systems are multipurpose systems capable of bonding composite to enamel, dentin, metal and porcelain [10]. These new adhesive systems can be used for intraoral repair of fractured porcelain restoration by bonding composite.

Different surface treatments like mechanical roughening of porcelain surface with coarse diamond. Sandblasting with aluminum oxide, acid etching with hydrofluoric acid, phosphoric acid are done to improve the surface area of contact and mechanical interlocking [6].

The repair technique includes surface preparation of porcelain and silane treatment in the bonding procedure [8]. The chemistry of newer systems varies from one manufacturer to other hence a study was conducted to evaluate the efficiency of the different bonding agents in reference to different surface preparation.

Materials and Methods

Preparation of the Sample

Sixty-three porcelain pellets (buttons) 6 mm diameter and 1.5 mm depth VITA MK95 porcelain powder mixed with liquid and fired according to manufacturers instructions. Three surface treatment and two bonding agents were evaluated. Surface treatment were sandblasting with 50 micron aluminum oxide etched with 35% phosphoric acid and 8% hydroflouric acid. Two bonding agents used were scotch bond adhesive (3M Germony), clearfil liner bond 2V (Kuraray Japan). Porcelain samples were grouped into 9, 7 pellets each group (groups I–IX).

Group I: Specimens were air abraded with 50 micron aluminum oxide for 10 seconds after sandblasting the specimens were cleaned with compressed air to remove the remaining powder.

Group II: Porcelain surfaces were etched with 35% phosphoric acid for 15 seconds and rinsed with water and dried with air spray for 20 seconds.

Group III: Porcelain surfaces were etched with 8% hydrofluoric acid for 4 minutes and rinsed with water and dried with oil free air spray for 20%.

Group IV: Specimens were sandblasted as in group I. Ceramic primer was applied and then scotch bond adhesive was applied using a brush and light cured for 10 seconds.

Group V: Specimens were sandblasted as in group I and then clearfil liner bond 2V was applied with a brush and surface was air dried.

Group VI: In this group the specimens were etched with 35% phosphoric acid as in group II then scotch bond adhesive acid was applied using a brush and later light cure for 10 seconds.

Group VII: In this group the specimens were etched with 35% phosphoric acid as with group II and then clearfil liner bond 2V was applied with a brush and air dried.

Group VIII: Specimen in this group were etched with 8% hydrofluoric acid as in group III and then scotch bond adhesive was applied using a brush and later light cure for 10 seconds.

Group IX: Specimen in this group were etched with 8% hydrofluoric acid as in group III and then clearfil liner bond 2V was applied with a brush and surface was air dried.

After surface treatment of the porcelain sample, a clear plastic tube measuring 4 mm diameter and 4 mm length was placed over the samples, composite resin was condensed inside the plastic tube and light cured for 60 seconds according to manufacturers instructions.

The specimens were stored in an incubator at 37°C for 24 hours to simulate mouth temperature before mechanical testing.

Shear testing of all groups was performed on Instron machine using a cross head speed of 2 mm/min. The shear debonding forces were recorded in kilograms and converted into MPA.

The stastical analysis of the bond strength data included – ANOVA one way analysis of variance and Duncan's Multiple Range Test.

Results

The mean shear bond strength of the 9 groups are shown in Table 1.

Group III demonstrated higher bond strength (5.90 MPA) compared to group I and group II (3.89). Group V showed higher bond strength the 7.54 MPA the group IV (6.24 MPA).

Group VII shows higher bond strength (9.73 MPA) then group VIII (7.60 MPA).

Group IX showed higher bond strength (9.78 MPA) then group VIII (9.24 MPA).

Table 1 Show the difference in shear bond strength between the groups (Group I to IX)

	Groups	Range	Difference Between Groups*							
			II	III	IV	V	VI	VII	VIII	IX
I	Sand blasting	3.06–4.68	NS	P < 0.01	P < 0.01	P < 0.01	P < 0.01	P < 0.01	P < 0.01	P < 0.01
II	Phosphoric acid	3.12–4.06	–	P < 0.01	P < 0.01	P < 0.01	P < 0.01	P < 0.01	P < 0.01	P < 0.01
III	Hydroflouric acid	5.34–6.63	–	–	NS	P < 0.01	P < 0.01	P < 0.01	P < 0.01	P < 0.01
IV	SB + Scotch bond	4.84–7.79	–	–	–	P < 0.01	P < 0.01	P < 0.01	P < 0.01	P < 0.01
V	SB + Clearfil	6.28–8.36	–	–	–	–	NS	P < 0.01	P < 0.01	P < 0.01
VI	Phosphoric + Scotch bond	6.74–9.49	–	–	–	–	–	P < 0.01	P < 0.01	P < 0.01
VII	Phosphoric + Clearfil	8.57–11.22	–	–	–	–	–	–	NS	NS
VIII	HF + Scotch bond	8.02–10.24	–	–	–	–	–	–	–	NS
IX	HF + Clearfil	8.55–11.05	–	–	–	–	–	–	–	–

Group III demonstrating higher bond strength than group I and II.

The difference between shear bond strength of group I (3.36) and group IV (6.24 MPA) was significant.

The difference between shear bond strength of group I and group V was significant. Although no statistically significant difference was observed between groups VI, VII and VII, group IX demonstrated highest bond strength. The difference between all groups are listed in Table 2 ($p < 0.01$, not significant).

Discussion

Fracture of a porcelain restoration is often considered as an emergency treatment and represent a challenge for the dentist [3]. Agents such as cynoacrylate, acrylic resin have been used to repair metal ceramic restoration with limited success, because of their inherent physical properties [11]. Composite resin has been the material of choice for their ease of manipulation and esthetic value.

Porcelain being glass in nature does not offer bonding to composite. Various methods have been introduced to repair fractured porcelain using a composite resin. Mechanical roughening of porcelain surface with a coarse diamond, air abrasion (sandblasting) with aluminum oxide, etched with hydrofluoric acid [12] and phosphoric acid [13], to facilitate micromechanical retention.

The mechanical bond possesses inherent disadvantages of microleakage [14]. Silane coupling agent which chemically bond organic and inorganic substance was first introduced in 1960 [15]. Bowen demonstrated the benefit of using vinyl silane as an organofunctional complex between the polymer and an organic substance in promoting the strength and quality of the bond [12] Various techniques

Table 2 Shows the range, mean and standard deviation for different groups (Group I to IX)

	Groups	Bond strength (Mpa)		
		Range	Mean	SD
I	Sand blasting	3.06–4.68	3.66	0.61
II	Phosphoric acid	3.12–4.06	3.59	0.41
III	Hydroflouric acid	5.34–6.63	5.90	0.50
IV	SB + Scotch bond	4.84–7.79	6.24	1.06
V	SB + Clearfil	6.28–8.36	7.54	0.77
VI	Phosphoric + Scotch bond	6.74–9.49	7.60	0.95
VII	Phosphoric + Clearfil	8.57–11.22	9.73	0.92
VIII	HF + Scotch bond	8.02–10.24	9.24	0.69
IX	HF + Clearfil	8.55–11.05	9.78	0.91

ANOVA F-Test ($F = 6.28$, $P < 0.01$)
Duncan's multiple range test
$P < 0.01$: Significant
NS: Not significant

for intraoral porcelain repair system that rely on chemical interaction are available [16].

Silanes were introduced by Bowen and Rodriguez who developed composite resin by adding silanated filler particle to BISGMA resin [15]. A silane coupling agent chemically bonds to the hydrolyzed silicondioxide of the ceramic surface and also it bonds to a methacrylate group at the other end copolymerize with the adhesive resin [12]. Chemical bonding to ceramic surface is achieved by silanization with a bifunctional coupling agent.

Etching increases the surface area and create microporosites, the composite resin flows into the porosities and interlocks thereby achieves strong micromechanical bond.

Bonding of resin to a ceramic surface in based on the combined effect of micromechanical interlocking and chemical bonding.

In present study, 3 types of surface treatments were carried out, sandblasting with 50 mm aluminum oxide, etching with 35% phosphoric acid, etching with 8% hydrofluoric acid 2 bonding agents used were scotch bond adhesive (3M) and clear fill liner bond 2V (Kuraray) applied to each of the surface treated porcelain samples. A total of 63 porcelain samples were made without any defect and were divided into 9 groups. Different surface treatments were carried out. Surface treated samples were further applied with bonding agents and composite resin was lightcured.

Sandblasting results into surface irregularities which improves the surface area of contact, sandblasting abrades ceramic surface, it does not create deeper cavaties where as etching with acids like phosphoric acid, hydrofluoric acid, causes greater roughness and increases the surface area as well as mechanical interlocking [12, 16]. In this study sandblasting showed least shear bond strength when compared to phosphoric acid and hydrofluoric acid, respectively. The shear bond strength of phosphoric acid was 3.12–4.06 ($p < 0.01$) which is higher than the sandblasting but lower than hydrofluoric acid etching (5.34–6.63 MPA).

Hydrofluoric acid etching showed higher bond strength when compared to other surface preparation. Hydrofluoric acid etching has been widely used because it showed higher bond strength. [17, 18].

Hydrofluoric acid causes greater roughness and its action is deeper, and it selectively dissolves glass particles and cause greater roughness thereby interlocking of the resin [19, 20]. Sandblasting + scotch bond adhesive showed higher bond strength when compared to sandblasting.

Pratt [11] found that 3M porcelain kit produced the stronger shear bond strength when compared to silanit enamelite 500, cerametal, porcelite sandblasting + clear fill liner showed higher bond strength when compared to sandblasting and sandblasting + scotch bond adhesive. Phosphoric acid + scotch bond adhesive acid showed higher bond strength when compared to phosphoric acid alone, phosphoric acid and scotch bond adhesive.

Kamada found that clear fill porcelain bond and 3M system maintain higher bond strength than other materials under thermal stresses [21].

Hydrofluoric acid + scotch bond adhesive acid showed higher bond strength when compared to hydrofluoric acid. Hydrofluoric acid + clear fill liner bond showed higher bond strength when compared to hydrofluoric acid and scotch bond adhesive acid. The present study 8% hydrofluoric acid etching showed higher bond strength when compared to 35% phosphoric acid etching and standblasting by 50 micron aluminum oxide. Hayawaka [18] suggested no need of hydrofluoric acid etching whenever saline coupling agents are used however in the present study use of etching and application of saline showed highest bond strength than any other group, this is indicative that the effect of saline and etching can be used to improve mechanicochemical bonding. Among the bonding agents used clear fill liner bond 2V showed higher bond strength when compared to scotch bond adhesive.

Conclusion

Within the limits of the study the following conclusions were drawn.

- Etching with 8% hydrofluoric acid provided higher bond strength when compared to 35% phosphoric acid and sandblasting with 50 micron aluminum oxide.
- Clear fill liner bond to be provided higher bond strength when compared to scotch bond adhesive.
- Hydrofluoric acid etching + clear fil liner bond provided highest bond strength than any other group.

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