

Comparison of Surface Conditioning Methods on Shear Bond Strength of Metal Brackets to Ceramic Surface - An in vitro study

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INTRODUCTION

As the demand for adult orthodontic treatment increases and the popularity of esthetic dentistry expands, orthodontists are more likely faced with the problem of placing orthodontic appliances on teeth restored with resin and porcelain fixed prostheses or veneer laminates. When esthetics is a concern, orthodontists will have to depend on the direct bonding technique.¹

ABSTRACT:

Aims and Objectives: The present study aimed to compare the shear bond strength of metal brackets on ceramic surfaces using different surface treatment methods. (i) 37% Phosphoric acid (ii) 9% HF (iii) Sand blasting (50-120 µm) and (iv) Extra fine bur (20-30 µm)

Materials and method: Forty ceramic facets were taken, resembling maxillary central incisor labial surfaces with thickness of 2mm. They were divided into four groups. In Group 1 surfaces were treated with Phosphoric Acid 37% and Silane. In Group 2 surfaces were treated with Hydrofluoric Acid 9 % and Silane. In Group 3 surfaces were treated with sand blasting (50-120 µm) and Silane. In Group 4 surfaces were treated using extra fine bur (20-30µm) and silane. Brackets were bonded to each conditioned ceramic surface with light curing composite resin. Then Specimens were tested on Universal testing machine for shear force required to debond the brackets. The Shear bond strength data were subjected to ANOVA Test.

Results: Surfaces conditioned with 9% HFA showed the higher bond strength followed by sandblasting, extra fine bur and 37% phosphoric acid.

Conclusion: Shear bond strength of metal brackets bonded to ceramic surfaces using the four different surface conditioning methods were adequate. 37% Phosphoric acid is the choice of surface conditioning to ceramic surfaces, since it has adequate bond strength. It is least harmful to oral mucosa compared to 9% Hydrofluoric acid and less cumbersome to use compared to Sandblasting and less destructive compared to extra fine bur.

Key words: Orthodontic bracket, Ceramic facets, Conditioning, Shear bond strength.

Buonocore introduced the acid-etch technique in 1955 by bonding acrylic resin to the enamel surface that had been pretreated with 85% phosphoric acid for 60 seconds. Since this initial report, various investigators have evaluated the technique to determine the factors that may effect the strength of the mechanical bond including: the type of enamel conditioner, acid concentration, and length of etching time.²

Numerous conditioning methods have been suggested for pre-treating ceramic surfaces.^{3, 4} Organosilane coupling agents are suggested to enhance bonding of brackets to ceramic.⁵ Hydrofluoric (HF) acid and acidulated phosphate fluoride were reported to facilitate micromechanical retention, but HF acid has been found to be a harmful and irritating compound for soft tissues. Furthermore, mechanical roughening with fine and coarse diamond burs and sandblasting are reported to provoke crack initiation and propagation within the ceramic. Because the restorations generally remain in the mouth after debonding the brackets, damage to the ceramic due to extreme roughening of the surfaces during pretreatment or debonding must be avoided.⁶ The present study aimed to compare the shear bond strength of metal brackets on ceramic surfaces using different surface treatment methods. (i) 37% Phosphoric acid (ii) 9% HF (iii) Sand blasting (50-120 μm) and (iv) Extra fine bur (20-30 μm).

Materials and Methods

Forty ceramic facets were taken, resembling maxillary central incisor labial surfaces with thickness of 2mm. These facets were placed on the metal casting. This entire casting along with ceramic facet was mounted in the dental plaster. They were divided into four groups (Figure 1).

Group 1: Surfaces treated with Phosphoric Acid 37% (60seconds) and Silane.

Group 2: Surfaces treated with Hydrofluoric Acid 9 % (90seconds) and Silane.

Group 3: Surfaces treated with sand blasting (50-120 μm) and Silane.

Group 4: Surfaces treated using extra fine bur (20-30 μm) and Silane.

Facets in each group were mounted vertically on dental plaster blocks. Facets were aligned with the facial surface of the tooth perpendicular with the bottom of the mold; i.e., each tooth was oriented so its labial surface would be parallel to the force during the shear strength test.

Transbond XT bonding system (3M Unitek) containing a liquid sealant and an adhesive paste, is used for bonding. Manufacturer's instructions were followed throughout the procedure. All forty Ceramic facets were conditioned according to groups. Application of silane coupling agent (Ultradent) done on conditioned facets with mini brush tip. Stainless steel central incisor metal brackets, (3M Unitek, Gemini M.B.T, Monorovia ,USA) used for bonding.

After bonding all specimens were stored at 37°C for 24 hrs in water to prevent dehydration of the specimens.⁷⁻¹⁰

A Customized jig was suspended from the crosshead of a UNIVERSAL TESTING MACHINE (TUE-C-400, Fine Spavy Associates & Engineers Pvt. Ltd., Miraj). A Gingivo-occlusal load was applied to de-bond the bracket, producing shear force at the bracket-tooth interface for all the four groups (Figure 2). A computer, electronically connected with the test machine, recorded the results of each test. Shear bond strengths were measured at a crosshead speed of 0.5 mm/min.

Statistical Analysis: Mean shear bond strength of different groups was determined using student t test. The level of significance (p value) was kept at 0.05. The Shear bond strength data were subjected to ANOVA Test.

Results

Surfaces conditioned with 9% HFA showed the higher bond strength (14.12 \pm 2.11MPa) followed by Sandblasting (13.14 \pm 1.30MPa), Extra fine bur (11.71 \pm 2.13MPa) and 37% Phosphoric acid (11.05 \pm 2.13MPa) (Graph I; Table 1). Statistically significant variations existed in the shear bond strength in group I with group II and group III; group II and group IV; and group III and group IV (Table 2 and 3) (Pd^{0.05}).

Discussion

It is important to prepare ceramic surfaces prior to bonding. Numerous types of acid etching solution with variable concentrations have been developed. These include hydrofluoric acid (HFA) gel (Zachrisson et al. 1996; Kocadereliet al. 2001), acidulated phosphate fluoride (APF; Major et al. 1995), and phosphoric acid gel and solutions (Yen et al. 1993). The most commonly used ceramic acid etchant is a 9.6 per cent HFA gel (Stangelet al. 1987).¹¹

There are few scientifically-based recommendations in the literature for a minimum orthodontic bracket shear bond strength. Whitlock et al. (1994), based upon the work of Reynolds, also suggested that 6–8MPa was adequate for orthodontic attachments and this was used in the present study.¹² The present study was conducted to find the most reliable method for bonding metal brackets onto ceramic crowns.

In the present study the silane application was combined with mechanical or chemical roughening to increase SBS. Silane application following surface

Table 1: Mean, SD, standard error and coefficient of variation of shear bond strength in four groups

Groups	Mean	SD	SE	CV
HF	14.12	2.11	0.67	14.97
Extra fine bur	11.71	2.13	0.67	18.17
37%phosphoric acid	11.05	1.94	0.61	17.54
Sandblasted	13.14	1.30	0.41	9.91

Table 2: Comparison of four groups (HF, Extra fine bur, 37%phosphoric acid, Sandblasted) with respect to shear bond strength by one way ANOVA

Source of variation	Sum of squares	Degrees of freedom	Mean sum of squares	F-value	P-value
Between groups	57.63	3	19.21	5.3207	0.0039*
Within groups	129.99	36	3.61		
Total	187.62	39			

*p<0.05

Table 3: Pair wise comparison of four groups (HF, Extra fine bur, 37% phosphoric acid, Sandblasted) with respect to shear bond strength by Newman-Keuls multiple posthoc procedures

Groups	HF	Extra fine bur	37% phosphoric acid	Sand blasted
Mean	14.1210	11.7110	11.0500	13.1410
SD	2.1134	2.1274	1.9379	1.3020
HF	-			
Extra fine bur	P=0.0200*	-		
37% phosphoric acid	P=0.0050*	P=0.4419	-	
Sand blasted	P=0.2565	P=0.1012	P=0.0483*	-

*p<0.05

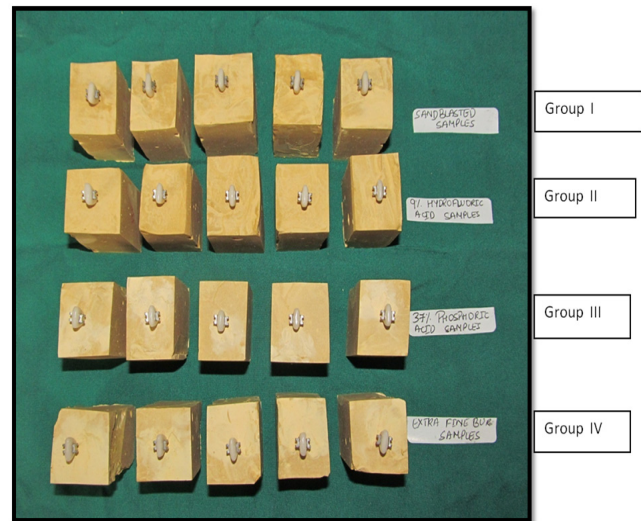
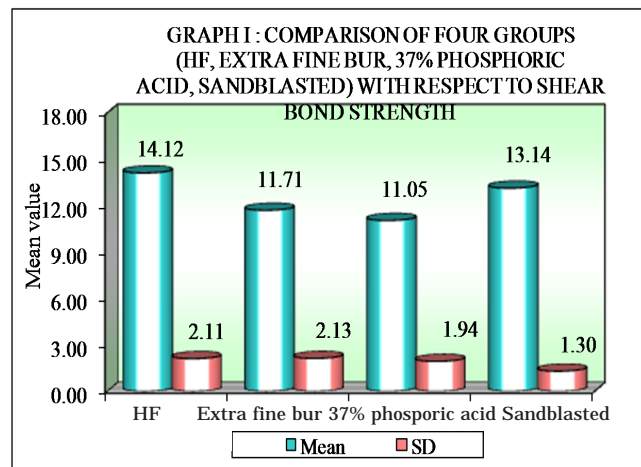


Figure 1: Samples Consisted of Four Test Groups (10 in Each Group). Group I: Surfaces treated with Phosphoric Acid 37% (60seconds) and Silane. Group II: Surfaces treated with Hydrofluoric Acid 9% (90seconds) and Silane. Group III: Surfaces treated with sand blasting (50-120µm) and Silane. Group IV: Surfaces treated using extra fine bur (20-30µm) and Silane.



Figure 2: Universal testing machine and customized jig with specimen. (a) Universal testing Machine (b) Customized Jig with specimen.

roughening provides a statistically significant increase in SBS (Wood et al. 1986; Kao et al. 1988; Smith et al. 1988; Kao and Johnston, 1991; Whitlock et al. 1994; Cochran et al. 1997; Chung et al. 1999; Huang and Kao, 2001; Kocadereli et al. 2001; Schmage et al. 2003). Silane presents a chemical link between the dental ceramic and the composite resin, and the organic portion of the molecule enhances the wettability of the ceramic surface, thereby displaying a closer micromechanical bond (Luet al.1992).^{3, 5}

In present study, extra fine bur group showed higher shear bond strength than phosphoric acid group, but less than HFA and Sand blasted group. Roughening the porcelain surface with a extra fine diamond, produced a random peeling appearance thus enlarging the porcelain surface area with only shallow mechanical retention.¹³ However, the differences were not observed among the groups, i.e. roughening with a diamond bur, chemical etching with HFA, and APA (Air particle abrasion) with Al₂O₃ particles (Sant'Anna et al. 2002). In another study, roughening with diamond burs without silane application showed lower bond strength than chemical etching with HFA with silane and APA with Al₂O₃ particles with silane (Schmage et al. 2003).³

In present study, Sand blasted group showed comparable shear bond strength with that of HF group, slightly less which is not clinically significant. Sandblasting particles produced a uniform peeling appearance of the porcelain with deeper penetration and more undercuts compared to roughening; this increased potential mechanical retention.¹³

Glaze removal has been advocated in order to create mechanical retention for the adhesive agent (Hulterstromand Bergman, 1993). Unfortunately, glaze removal by a diamond bur or green stone may damage porcelain by scoring the surface and an additional disadvantage of glaze removal is a reduction of 50 per cent in transverse strength (Phillips, 1991). Sandblasting with microscopic particles of aluminium oxide to remove glaze may be better than using burs or stones since only a small amount of surface is removed and the procedure is more uniform (Zachrisson et al. 1996).⁴

Direct transfer of this value to clinical situations is not universally accepted because the bracket-ceramic bond is influenced by many environmental factors. Even though the clinical relevance of in vitro studies is limited, they are essential in testing new methods before they can be used in vivo.

Conclusion

The following conclusions were drawn from the present study: Shear bond strength of metal brackets bonded to ceramic facets using the four different surface conditioning methods were adequate. On comparison of four different surface conditioning methods, 9% Hydrofluoric acid showed higher shear bond strength followed by sandblasting (50-120µm), extra fine bur (20-30µm) and 37% phosphoric acid respectively. 37% Phosphoric acid is the choice of surface conditioning to ceramic surfaces, since it has adequate bond strength. It is least harmful to oral mucosa compared to 9% Hydrofluoric acid and less cumbersome to use compared to sandblasting and less destructive compared to extra fine bur.

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