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Comparative assessment of hydrofluoric acid and sandblasting etching technique on porcelain crowns

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Abstract

One of the challenges the orthodontist face is how to increase bond strength between the brackets and tooth, various ceramic restorations or porcelain crowns. Bond strength can be affected by bracket type and design of their base, bonding adhesive, or etching technique. **Aim**: To evaluate and compare the effects of sandblasting and hydrofluoric acid etching on shear bond strength (SBS) of metallic orthodontic brackets, bonded to porcelain crowns surfaces used for prosthetic restorations. Silane coupling agent was used as bond strength enhancer in both the cases. **Methodology:** Thirty porcelain maxillary central incisor crowns were used in the study. The crowns were divided randomly into two groups: Group H- the porcelain crowns were etched with 9% hydrofluoric acid followed by application of silane and the brackets were bonded with a composite adhesive, Group S the porcelain crowns were microetched with 50 microns Al_2O_3 particles followed by silane application and metal brackets were then bonded with the composite adhesive. All bonded crowns were stored in distilled water for 1 week at 37.8 ^{0}C before debonding. **Result:** The mean Shear bond strength values were significantly higher (*p=0.001*) in Sandblasting group than 9% Hydrofluoric acid with the mean±SD values as 12.6493±1.15084 and 7.4540±.54742 respectively. However, all SBS values in the present study were above the optimal range for orthodontic bonding (6-8MPa), rendering them clinically acceptable.

Keywords: Bonding on Porcelain, Hydrofluoric acid etching, Sandblasting, Shear bond strength.

Introduction

A more demanding sense of esthetics has lead to an increase in adults requesting for orthodontic treatment. Thus, orthodontists now a day frequently encounter ceramic restorations which are gaining popularity because of their superior biocompatibility and distinct esthetic appeal.

However, the difficulty that clinician faces while bonding a bracket to porcelain is that porcelain surface essentially is inert i.e. it does not adhere readily to other materials. The conventional orthodontic bonding system does not guarantee enough adhesion to porcelain to withstand orthodontic forces.

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So, the routinely followed method of placing attachments on these surfaces is by either banding or by removing the crown entirely and have a processed "temporary"fabricated, so that direct bonding can be done.There alternatives are neither esthetic nor cost effective. Also, banding has the disadvantage of separation pain, increased plaque accumulation, gingival inflammation and interproximal loss of attachment. Therefore, a method of bonding orthodontic attachments to these artificial surfaces would certainly be advantageous.

Over the past few years, several mechanical and chemical retention systems have been developed in an attempt to bond attachments to porcelain surfaces e.g. use of silane (a coupling agent), deglazing the porcelain by roughening the surface with diamond burs, air particle abrasion with aluminum oxide and chemical preparation with acids(phosphoric acid, hydrofluoric acid or acidulated phosphate fluoride).Laser etching is latest technique which is still under development.The choice between methods should be that whichprovide good bracket bond strength and preservation of ceramic surface after debonding.

In typical dental applications, concentrations of 4 % to 10% HF are typically utilized.Studies have shown that etching with HF results in very definitive microscopic etching pattern.[4]However there is a little drawback of HF that its use in-vivo especially in higher concentration is hazardous(Jochen).[9]Mucosal contact with HF can cause erythema and burning associated with loss of tissue. To overcome this drawback, buffered hydrofluoric acid (BHF) with reduced toxicity was introduced(Kicrkpatric and Burd[10]1995, Schiette catte et al [11]2003).For this reason, it was decided to use buffered hydrofluoric acid (9% HF) in this study.

Another approach used to enhance bond strength to porcelain surface is by changing the nature of the surface using a coupling agent such as silane. The action of the silane coupler can be observed as performing two functions; the hydrolysable group of coupler reacts with inorganic dental porcelain whereas its organofunctional group reacts with the resin and enhances the adhesion.

Zachrisson et al[12] (1996) promoted sandblasting as another mechanical retention procedure. Aluminium oxide particles are blasted onto the ceramic layer at high pressure leaving a microretentive surface. This method homogenously abrades the ceramic layers.

Considering this background, it was observed that while other alternatives do exist they are less predictable, especially over long term when compared to Hydrofluoric acid etching and sandblasting.

Therefore an in vitro study was designed to compare the shear bond strength of brackets bonded to porcelain using two most practical methods: Hydrofluoric acid etching and sandblasting to achieve satisfactory bond strength using silane as bond strength enhancer in both the cases.

Materials and Method

Study Design-

Thirty porcelain crowns (Dentsply Ceramco, Dentsply internal Inc York, PA, USA) of right side maxillary central incisor were fabricated and glazed in a dental laboratory according to manufacturer's specification.These specimens were mounted with autopolymerising acrylic resin (DPI-RR Cold Cure Acrylic Repair Material Dental Products of India, Mumbai) and were randomly divided into two groups (n=15) according to the surface conditioning methods, Group H(hydrofluoric acid etching) and Group S (sandblasting).The samples were then color coded, Group H samples were painted green (fig-1) and Group S samples yellow (fig-2).

Fig-1: Group H

Fig-2: Group S

Bonding procedure

GROUP H: In group H the porcelain surface was etched with 9 percent buffered hydrofluoric acid (Ultradent porcelain etch, Ultradent product inc. South Jordan,Utah, USA) for 90 secondsaccording to product specifications (fig-3).The surface was then thoroughly rinsed with water spray and air dried, after that Silane(Ultradent product inc. South Jordan,Utah,USA) was applied to the porcelain surface and allowed to evaporate for 60 seconds, if not completely dry after 60 seconds, samples were air dried with oil free compressed air.

This was followed by application of an adhesive primer (Transbond^{TM}XT; 3M Unitek, Monrovia,Calif) to the surface.A light cure microfilled resin (Transbond^{TM}XT; 3M Unitek, Monrovia,Calif) was applied to the mesh base of maxillary central incisor bracket (American Orthodontics, Mini-Master Series, 0.022 MBT 390-

1016).The bracket was seated and positioned manually and cured for a total of 20 seconds from two direction (interproximally) using a visible light curing unit with an output of 600 mw/cm^2 (Dentsply QHL75^{TM}).**GROUP S:**The Porcelain surface was sandblasted with 50-micron Al_2O_3 particles(Delta labs,Chennai,India) via a sandblasting machine (Dual Blaster, Delta Dental Lab Equipment,Chennai,India) from a distance of approx. 10 mm at a pressure of 5 bar(36 psi) for 10 seconds.This was followed by silane application, Primer application and bonding of the brackets using same criteria and materials as of group H samples.All the specimens were stored in distilled water for 1 weekat 37.8 ^{0}C.This was followed by thermocycling of specimens 500 times between 5^0 Cand 55^{0}C with a dwelling time of 30 seconds.

Fig-3: Application of hydro fluoric

Fig-4: Bonded samples

The shear bond strength test was performed with a Universal testing device (ACME Engineers, India) with a cross head speed of 1 mm per minute (Fig-5).The maximum load at which bracket debonded was recorded and the bond strength of samples were calculated in megapascles.

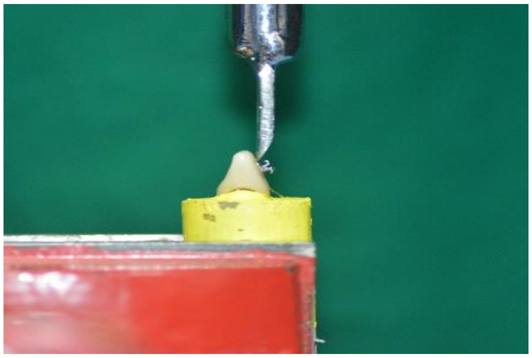

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Fig-5: Universal testing device

Result: Results obtained are shown in tables:

Table 1: Bond strength values of all the samples of Group H

Group-H: Hydrofluoric acid 9% Ultradent			
Sr.No.	**Sample ID**	**Maximum Load (N)**	**Shear Bond Strength (MPa)**
1	No.1	76.27	6.72
2	No.2	84.37	7.40
3	No.3	78.06	6.88
4	No.4	90.55	7.98
5	No.5	82.26	7.25
6	No.6	82.00	7.23
7	No.7	72.12	6.35
8	No.8	88.16	7.77
9	No.9	81.45	7.18
10	No.10	94.26	8.26
11	No.11	85.63	7.51
12	No.12	83.43	7.35
13	No.13	92.52	8.15
14	No.14	91.00	8.02
15	No.15	88.00	7.76
Average			**7.45**

Table 2: Bond strength values of all the samples of Group S

Group-S: Sandblasting			
Sr.No.	Sample ID	Maximum Load (N)	Shear BondStrength (MPa)
1	No.1	129.22	11.39
2	No.2	173.35	15.28
3	No.3	145.47	12.82
4	No.4	136.00	11.99
5	No.5	141.37	12.46
6	No.6	131.42	11.58
7	No.7	148.05	13.05
8	No.8	131.25	11.57
9	No.9	154.17	13.59
10	No.10	124.30	10.96
11	No.11	137.00	12.08
12	No.12	142.00	12.52
13	No.13	147.00	12.96
14	No.14	150.30	13.25
15	No.15	161.55	14.24
Average			**12.64**

Statistical analysis

The recorded data was compiled and entered in a spreadsheet computer program (Microsoft Excel 2007) and then exported to data editor page of SPSS version 20.0 (SPSS Inc., Chicago, Illinois, USA).

Descriptive statistics include the mean, standard deviation and individual values were calculated for each sample of both group. The data was found to be normal by Kolmogorov Smirnov test hence parametric test was applied. For comparing mean values,one-way ANOVA (intergroup comparison) followed by Tukey's test (intragroup comparison) was used as quantitative analysis. Level of significance was set at 0.05.

The mean values of Maximum load was compared by using Student's t-test intergroup comparison and the findings revealed that the mean values of Sandblasting (143.4967±13.05915) was very highly significantly different *(p=0.001*) from the mean values of Hydrofluoric acid 9% (84.6720±6.26277).

Table 3: Comparison between the groups on the basis of Maximum Load

Groups	Mean	Standard deviation	Standard error	p-value
Sandblasting	143.4967	13.05915	3.37186	0.001
Hydrofluoric acid 9%	84.6720	6.26277	1.61704	

Test applied: Student's t-test; p≤0.001 (Highly significant)

Also Shear bond strength values of two groups were compared for which Student's t-test (intergroup comparison) was used. It was found that the mean Shear bond strength values were significantly higher (p=0.001) in Sandblasting group than 9%Hydrofluoric acid with the mean±SD values as 12.6493±1.15084 and 7.4540±0.54742 respectively.

Table 4: Comparison between the groups on the basis of Shear bond strength

Groups	Mean	Standard deviation	Standard error	p-value
Sandblasting	12.6493	1.15084	.29715	0.001
Hydrofluoric acid 9%	7.4540	.54742	.14134	

Test applied: Student's t-test; p≤0.001 (Highly significant)

Discussion

When bonding orthodontic brackets to porcelain surfaces, it is necessary to change the inert characteristics of the surface to achieve clinically acceptable bond strength. This alteration is accomplished by either increasing the roughness of the porcelain surface mechanically eg. by either microetching(sandblasting) or the use of strong etchants such as hydrofluoric acid or both, together with a silane coupling agent.

In the present study, lower SBS value was found with Hydrofluoric acid group (Mean=7.45 Mpa) in comparison to Sandblasting group (Mean =12.64).There was a significant difference in the values of two groups.

Clinically adequate bond strength for a metal orthodontic bracket to enamel should range from 6 to 8 MPa as suggested by Reynolds.[13] All SBS values in the present study were above this optimal range, rendering them clinically acceptable.

Air particle abrasion roughens the ceramic surface by particle removal, whereas hydrofluoric acid roughens the ceramic surface by dissolving the crystalline and the glassy phases of the ceramic. Because of this, mechanical surface conditioning seems to be more effective than chemical conditioning. Studies have shown that chemical roughening with HFA showed more unchanged glazed surfaces and fewer pits. Mechanical roughening with sandblasting displayed loss of the glazed surface and an erosive appearance with shallow penetration and undercuts.

Adhesive failures at the porcelain/composite interface are preferred to avoid porcelain fractures during debonding[14].It has been reported that if bond strengths between the porcelain and the composite resin are higher than 13 MPa, cohesive failures are observed in the porcelain[15].

Andreasen and Stieg[14] found that fracture of the porcelain itself was experienced during both tensile and shear testing when the silane coupling agents were used to increase the bond strength of orthodontic adhesives. The majority of these fractures were found in the shear sample group.

Newman[15]also reported that the strength of the bond between the resin and porcelain, attained with the use of a silane coupler, was sufficient to cause the fracture of porcelain. Such an occurrence is undesirable when associated with the removal of orthodontic brackets from porcelain crowns on restored teeth.

In this study the mean value for sandblasting group was 12.64 MPa and porcelain fractures or cracks were not observed .This observation is clinically important because a lack of macroscopic damage to the porcelain surface indicates the long-term integrity of the restoration.

However a mean value of 12.64 Mpa and few values higher than 13 Mpa obtained in sandblasting group in this study indicates that clinician should be extremely cautious when using sandblasting +silane method to prepare porcelain, because debonding may result in a fracture or a crack in the porcelain surface.

Newman[15] suggested that when debonding orthodontic brackets from a porcelain surface, a ligature cutter be applied on the mesial and distal aspects of the bracket base and then twisted gently. Another approach used for bracket removal is by squeezing the mesial and distal bracket tie wings together, thus distorting the bracket. The residual composite can then be removed with a scaler or a slow speed finishing bur or both.

Chemical roughening with HFA has been reported to be effective for improving bond strengths. [2,3,12,16] Present study also showed that hydrofluoric acid can provide clinically adequate bond strength. (Mean SBS 7.45 Mpa)

Disagreement exists concerning the effectiveness of APA(air particle abrasion) with Al_2O_3 particles: In present study APA with Al_2O_3 particles was more effective than chemical etching with HFA. However, in some studies no significant difference was reported between sandblasting and chemical etching. [16]
It should be emphasized that the differences between in vitro vs in vivo bond strengths need to be considered carefully, especially when bonding bracketsto other restorative dental materials. Andreasen and Stieg[14]indicated that the shear and tensile bond strengths of in vivo incisor and premolar enamel were significantly less than those of in vitro incisor and premolar enamel. They suggested that part of the in vivo increase in the rate of deterioration may be because of the mechanical and masticatory stresses placed on the bonds in the oral environment. They calculated that there was a decrease of approximately17% to 22% in tensile strengths and 48%to 52% in shear strengths in vivo when compared withthe in vitro bond strengths. They suggested that if thispercent of in vivo decline is evident when bonding toporcelain surfaces, stronger bond strength would be required for the efficient bonding of orthodontic bracketsin the actual patient.With this in mind, it seems that the clinician and thepatient are better served by using microetching rather than hydrofluoric acid etching.

Conclusion

- Shear bond strength values were found to be above the optimal range (6–8 MPa) for all the samples of both the group.
- Bond strength of Group S samples (microetched with 50 micron aluminium oxide particles) were more compared to that of Group H samples (treated with 9% hydrofluoric Acid).
- Considering the dangers of acid burn and other deleterious effects of hydrofluoric acid, Sandblasting seems to be the better method of bonding brackets to the porcelain surface.

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