Bonding of Orthodontic Brackets to Porcelain Surfaces- An Overview.

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ABSTRACT

As people all over the world are putting greater emphasis on self-improvement, and with recent advances in orthodontic technology and aesthetic materials, more adults are seeking orthodontic treatment. As a result, orthodontists are faced with the challenge of bonding to porcelain restorations (crowns, veneers). This has presented quite a challenge in the past, but using the proper materials and following the necessary procedure can ensure a reliable bond. The following article gives an overview of the literature for various techniques used for bonding orthodontic brackets to the porcelain surfaces to know which method is more reliable for porcelain bonding.

Keywords: Bonding, Brackets, Porcelain, Orthodontics.

INTRODUCTION

With the increase in adult orthodontic treatment comes the need to find a reliable method for bonding orthodontic brackets onto metal or ceramic crowns and fixed partial dentures. Most dental ceramic and metal cramic crowns, bridges and veneers presently are made from different feldspathic porcelains containing from 10% to 20% aluminium oxide. However, such restorations also can be made from high-aluminium porcelains and glass ceramics.

Conventional acid etching is ineffective in the preparation of porcelain surfaces for mechanical retention of brackets. In 1968, Wood et. al. showed that roughening the porcelain surface, adding a porcelain primer, and using a highly filled adhesive resin when bonding to glazed porcelain added progressively to bond strength.

There are two variable options when bonding to porcelain

1. Bond it mechanically by etching the porcelain with hydrofluoric acid or
2. Bond it chemically using a silane coupling agent.

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The disadvantages of a hydrofluoric acid etch are that

1. It involves using a potentially dangerous acid.
2. It creates a porous, roughened surface in the porcelain, much like etched enamel (removes outer glaze).

Silane coupling agents are provided in the form of porcelain primers. It chemically unites the silicon in porcelain to the acrylic bonding material used. They are hybrid inorganic-organic bifunctional molecules that create a siloxane network with the hydroxyl(OH) groups on the HF-etched hydrophilic glass ceramic surface and copolymerize with the hydrophilic resin matrix of the composite.

REVIEW OF LITERATURE

An in-vitro study done by Eustaquio,[1] 1988 comparing bond strengths of glazed and unglazed porcelain samples found no statistical difference in the bond strengths.

In 1996, Zachrisson did a study to compare the bond strengths.[2] Sandblasted & silane treated samples had a mean bond strength of 11.6 MPa (S.D. 2.9) and sandblasted and hydrofluoric acid etched samples had a mean of 11.5 MPa (S.D. 2.8). The conclusion stated that there was no significant difference in bond strength between the two.

A study was done by Schmage et. al.,[3] 2003 to examine the effect of four different surface conditioning methods viz. fine diamond bur, sandblasting, 5% hydrofluoric acid and silica coating for bonding metal brackets to ceramic surfaces of feldspathic porcelain. Chemical surface conditioning with either hydrofluoric acid or silicatization resulted in significantly lower surface roughness than mechanical conditioning, diamond bur and sandblasting (P < 0.001). Bond strengths of the brackets bonded to the ceramic surfaces treated by hydrofluoric acid with and without silane (12.2 and 14.7 MPa, respectively), silicatization (14.9 MPa) and sandblasting with silane (15.8 MPa) were significantly higher (P < 0.001) than those treated by mechanical roughening with fine diamond burs (1.6 MPa) or sandblasting (2.8 MPa). The highest bond strength values were obtained with sandblasting and silicatization with silane or hydrofluoric acid without silane; these fulfilled the required threshold. The use of silane after hydrofluoric acid etching did not increase the bond strength. Diamond roughening and sandblasting showed the highest surface roughness; they can damage the ceramic surface. Acid etching gave acceptable results for clinical use, but the health risks should be considered. The silicatization technique has the potential to replace the other methods; yet cohesive failures were observed in the ceramic during removal of the brackets.

Gursimrit et al.,[4] 2014 did a systematic review to determine which materials and technique/protocol present the highest success rate in bonding brackets to porcelain surfaces. Several techniques have been used to bond brackets to porcelain surfaces. Laser irradiation by Nd:YAG laser is an acceptable substitute for hydrofluoric acid, however, Er-YAG laser is not an acceptable option. The optimum concentration that increased bond strength was 9.6% HF, but no significant difference was found between the groups etched with 9% and 5% hydrofluoric acid. Longer etching time increases the bond strength as it allows the acid to react with the ceramic matrix and partially dissolve it. The specimens etched for 60 seconds showed significantly higher bond strengths than the specimens etched for 20 seconds. Deglazed porcelain surface and beads base design of the bracket yielded the highest shear bond strength. Silane application significantly increased the bond strength. IPS Empress group showed the weakest bond strengths. The different conventional techniques that were shown to be most effective on the different ceramic surfaces were silica coating on feldspathic and lithia disilicate-based ceramic. The conventional technique that yielded the lowest shear bond strength for ceramic surfaces was sandblasting surfaces alone. The protocol that resulted in the highest shear bond strength was etching the porcelain surface with 9.6% hydrofluoric acid and applying silane or a bonding agent. This procedure produced higher shear bond strength than groups that were etched with acidulated phosphate fluoride, silane, and sandblasting by diamond burs or aluminum oxide particles, or sandblasting and etching alone. Air particle abrasion at a pressure of 2.5 bars for 4 seconds and etching with hydrofluoric acid produced higher shear bond strength than using hydrofluoric acid alone.

The use of hydrofluoric acid greatly increases the bond strength. This is due to the acid's ability to react with the silica phase, which creates micromechanical retention through microchannels. Over time, the glassy matrix partially dissolves and increases the formation of retentive channels. The etching of HFA ultimately increases the surface area, which helps penetrate the resin cement into the microchannels created. Therefore, the longer etching time increases the bond strength as it allows the acid to react with the ceramic matrix and partially dissolve it. Since there was no significant difference between the 5% and 9.6% HFA groups, it is suggested that the use of 9.6% HFA is not necessary to achieve higher bond strength. Porcelain surfaces treated with silane concluded that the bond strength of brackets to porcelain surfaces was improved by the application of silanes. The reason is that silane forms chemical bonds with inorganic and organic surfaces, which ultimately increase the bond strength. The studies also proved that another efficient conditioning method was roughening the surface by a diamond bur or sandblasting.

The best protocol described in this review is 9.6% hydrofluoric acid etched for 1 minute, rinsed for 30 seconds, and then air-dried.[4] The etching of hydrofluoric acid should be followed by an application of silane. Considering the harmful effects of etching with HFA, another appropriate step is mechanical roughening with sandblasting followed by an application of silane.

Raed Ajlouni et al.,[5] 2005 did a study to evaluate the effects of a new self-etching primer/adhesive used to enhance the shear strength of orthodontic brackets bonded to porcelain surfaces. Forty-five porcelain maxillary central incisor teeth were used in the study. The teeth were divided randomly into three groups: group I (control), the porcelain teeth were etched with 37% phosphoric acid followed by a sealant and the brackets were bonded with a composite adhesive; group II, the porcelain teeth were microetched and hydrofluoric acid and silane applied and metal brackets were then bonded with the composite adhesive; and group III, the porcelain teeth were etched with phosphoric acid and a self-etching primer/adhesive applied before bonding. Brackets precoated with the adhesive were used on all three groups of teeth. All teeth were stored for 24 hours at 37 ○C before debonding. The results of the analysis of variance (F = 10.7) indicated that there was a significant difference (P = .001) between the three groups. The mean shear bond strengths of conventional bonding using a 37% phosphoric acid and sealant was 4.4 ± 2.7 MPa, whereas that of microetching followed by the application of hydrofluoric acid and silane was 11.2 ± 4.7 MPa, and for the new self-etching primer/adhesive it was 10.3 ± 5.3 MPa. The last two groups had the highest bond strength values and were not significantly different from each other.

Yusir and Nidhal,[6] 2010 did a study to evaluate the effect of different methods of porcelain surface treatments on the bond strength of metal bracket bonded directly using One-Step orthodontic adhesive and study the mode of bond failure. Sixty maxillary right central incisor porcelain denture teeth were randomly divided into six groups(Gp), ten specimens for each; Gp.I(P): phosphoric acid 37% (control), Gp.II(PS): phosphoric acid 37% & silane coupling agent, Gp.III(HS): hydrofluoric acid 9% & silane coupling agent, Gp.IV(SP): sandblasting with 50 µm Al2O3 particles & phosphoric acid 37%, Gp.V(SPS): sandblasting with 50 µm Al2O3 particles, phosphoric acid 37% & silane coupling agent, Gp.VI(SHS): sandblasting with 50 µm Al2O3 particles, hydrofluoric acid 9% & silane coupling agent. Metal brackets were bonded to treated porcelain surfaces using One - Step orthodontic adhesive. After thermocycling the shear bond strength (SBS) & mode of bond failure were determined. One Way ANOVA-test showed a statistically highly significant difference ($p = 0.000$) in SBS of the non-sandblasting groups and also showed a statistically highly significant difference ($p = 0.000$) of the sandblasting groups. SHS Gp. had the highest values in mean shear bond strength (6.459 ± 13 Mpa) of all groups followed by HS Gp.(3.961 ± 0.9 Mpa) then SPS Gp.(2.096 ± 0.5 Mpa) then SP Gp.(1.16 ± 0.8 Mpa).On the other hand both P & PS groups had zero Mpa values of SBS.

The most reliable procedure for bonding orthodontic brackets to porcelain surfaces is through the surface treatment combinations of three methods: sandblasting, 9% hydrofluoric acid treatment and silane coupling agent application. On the other hand all other methods produced insufficient SBS for orthodontic treatment. Adhesive-porcelain interface failure was the predominant mode of bond failure in all groups except the last group, cohesive failure was the predominant & none of the samples displayed fractures within the porcelain itself during debonding.

According to Graber,[7] sandblasting and silane bonds have been found to be unreliable, with unacceptably high failure rates, whereas the hydrofluoric acid gel-conditioned bonds to porcelain have proven to be excellent throughout full routine orthodontic treatment periods. The addition of silane (Scotchprime) after sandblasting and hydrofluoric acid treatment did not influence the bond strengths significantly (failure rates of 8.2% versus 8.6%).

For optimal bonding of orthodontic brackets and retainer wires to porcelain surfaces, the following technique is recommended:[7]

1. Isolate the working field adequately, band the actual crown separately from the other teeth.
2. Use a barrier gel such as Kool-Dam on Mandibular teeth to prevent HF gel contact with gingival or soft tissues.
3. Deglaze an area slightly larger than the bracket base by sandblasting with 50 µm aluminium oxide for 3 seconds.
4. Etch the porcelain with 9.6% hydrofluoric acid gel for 2 minutes.
5. Carefully remove the gel with cotton roll and then rinse using high-volume suction.
6. Immediately dry with air, and bond bracket.

The use of a silane is optional.

HF will not be effective for bonding to high-alumina porcelains and glass ceramics, and new technique improvements eg. silica coating are needed for successful bonding.

Procedure

1. Thorough prophylaxis of the tooth to be bonded should be done. Then rinse and dry the tooth adequately.
2. Micro-etch the crown and then rinse and dry.
3. Place Barrier gel on gingival margin.
4. Place porcelain etchant on the crown. Leave for 4 minutes. Then rinse and dry.
5. Apply one thin layer of porcelain conditioner. Leave for one minute.
6. Apply one coat of Universal bonding Resin and air dry.
7. Proceed with the application of paste and bond the bracket.

Some authors have claimed that the composite-porcelain bond is mostly micromechanical and that the contribution of the silane application for a chemical bond to most feldspathic porcelains is negligible. The most commonly used porcelain etchant is 9.6% hydrofluoric acid in gel form applied for 2 minutes. HF is strong and requires bonding separately to other teeth, careful isolation of the working area, cautious removal of gel with cotton roll, rinsing with high-volume suction, and immediate drying and bonding. The etchant creates microporosities on the porcelain surface that achieves a mechanical interlock with the composite resin. The etched porcelain will have a frosted appearance similar to that of etched enamel.[8]

Debonding Considerations [7,9]

A gentle technique is necessary to achieve failure at bracket-adhesive interface and avoid porcelain fracture. The best method is to use a peel-type force, which is applied by distorting the bracket. With a twin-type bracket, gently squeeze the bracket wings together with a plier. This will separate the bracket from the adhesive underneath, leaving an adhesive layer on the porcelain crown, which is then removed with a tungsten carbide finishing bur, sanding discs. Smoothing is achieved with slow-speed polishing rubber wheels and enamel-like gloss by using diamond polishing paste in rubber cups.

CONCLUSION

As more adults seek orthodontic treatment, we are often faced with the challenge of bonding to porcelain crowns and veneers. Though this requires following a detailed procedure and using both safe and effective bonding materials, the result is a reliable bond that does not compromise the integrity of the porcelain surface.

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