The study of composite bracket bond strength on porcelain surface

Chia-Tze Kao and Tsui-Hsien Huang

Recent progress in materials and techniques suggest that direct bonding of orthodontic attachments to surface other than enamel may now be possible. To test the effectiveness of bonding orthodontic attachments to porcelain teeth, composite brackets (Spirit MB, Ormco, USA) were bonded to 80 porcelain teeth by means of Unitek self cure nonmixed resin system (Unite, 3M) 40 teeth and Unitek light cure bonding resin system (Transbond, 3M) 40 teeth. By following the routine procedure of bonding to porcelain, the porcelain surface were treated with or without acid eatching, applied the primer (silain coupling agent , 3M, USA) to the porcelain surface, then using the different bonding system bond the bracket to the porcelain. The sample were thermocycled 500 times, changed with the temperature 60 ℃ in warm water and 4℃ in cold water. The sample were tested by universial testing machine (Shimadzu, Japan), the shear force were recorded. The data were analysed by statistic method. The result showed that the shear force on the group with nonmixed resin and acid etching has high shear force. The shear force on the group without etching treatment is lower than those with etching treatment. Generally the bonding force of composite bracket bonded to porcelain is acceptable on clinical application.

Key word: composite bracket, porcelain, hydrofluoride acid, bonding strength.

Introduction

Bonding in orthodontic is the key role on the beginning of fixed orthodontic treatment. The introduction of the acid etch bonding technique has led to dramatic changes in the practice of orthodontics.[1] Bonding has many advantages over banding in orthodontic practice. As a result of increased bonding strength, orthodontic attachments can be bonded in place where banding is difficult or physically impossible.

The orthodontist are routinely faced with

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the difficulties in bonding orthodontic attachments to various restorative materials including porcelain crown, bridges or veneers.[2] The orthodontist must find a procedure that allows orthodontic bracket to be bonded to porcelain restorations. There are suggestion on clinical steps for efficiency when bonding to porcelain.[2]

The glazed surface is not responsive to adhesive penetration and, if the surface is roughened to provide mechanical retention, it may not be acceptable after debonding.[3] In late 1970s organosilanes were gaining popularity in the field of prosthodontics for porcelain repair[4] and in the field of orthodontics for direct bonding of attachements to porcelain.[5] For a permanent chemical bond to form between the porcelain and the resin, the follows must occur: 1. hydrolysis of organosilane to form an organosilanol. 2. initial formation of oxane linkage, and 3. condensation reaction to form permanent oxan bond.[6]

In recent years, many studies have demonstrated that the use of silane coupling agents, or porcelain priming agents, will increase the strength of the bond to dental porcelain.[7-9]. Several articles have indicated that bond strengths approximatly that of bonding to enamel could be achieved by using organosilane primers in conjunction with traditional bis-GMA adhesives, but not all primers were equally effectives.[6,10,11] Recent research has shown that finding a proper adhesive-primer system and porcelain pretreatment, including acid etch or mechanical roughing, can have a large effect on the nature of bond failure and incidence of porcelain fracture.[11-13]

Current interest has been directed toward a bond strengths between cosmatic bracket-plastic brackets and porcelain teeth. The composite brackets (also named plastic bracket) are made of polycarbonate and are used mainly for esthetic reason.[14] Such composite brackets may be useful in minimal force situations and for treatment of short duration, particularly in adults.[15]

Many studies have evaluated the bond strength of stainless steel and ceramic brackets bonded to enamel. Orthers have evaluated different combinations of adhesives and porcelain primers used to bond stainless steel brackets or ceramic brackets to porcelain. However, no studies have evaluated the bond strength of composite brackets to porcelain crown. Therefore the purpose of this study was to evaluate the shear bond strengths produced when two bonding materials were used alone and in combination with acid etch agent to bond composite brackets to dental porcelain, and to examine the effects on the surface of the porcelain after bond failure.

Materials and method

Bonding to porcelain teeth

The porcelain teeth preparation

Eighty standardized porcelain fused to metal teeth (Shou Fu, Japan) were constructed and fixed according to the manufacturer's recomendations. The porcelain teeth were stored in 100% humidity at 37°C distilled water until the bonding procedure began.

Bonding procedure: (chart 1.)

The eighty samples were divided into two groups such that 40 samples were bonded with unit adhesive (Unitek 3M, USA) and 40 samples were bonded with light cure adhesive (Unitek 3M, USA). Each group was then divided into 2 subgroups of 20 so that each adhesive was paired with a 9.6% HF (Hydrofluoric acid, 3M St Paul, Minn) applied; and without HF applied.

The porcelain-laminated labial surface of the teeth were modified with a green stone to roughen the surface glazing. 40 samples were

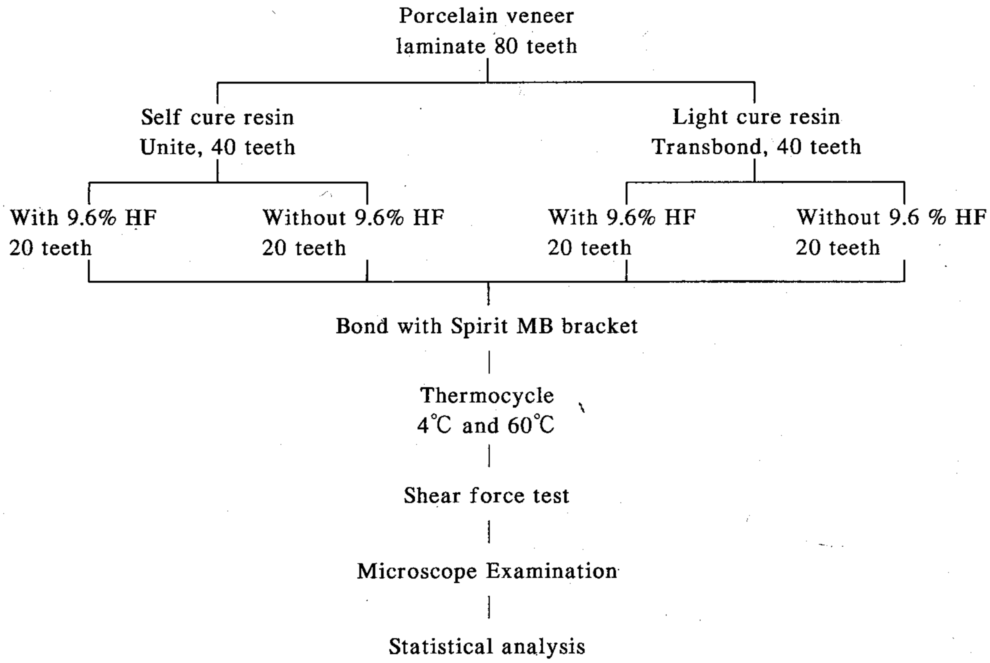

Chart 1. The flow of the bonding procedure.

etched with HF 3 minutes, washed out with water and dry the surface. At this moment, water line should be clean and oil free so as not to contaminate the surface. Scotchprime was applied in two layers with a pledget and air dried gently. The 80 spirit mechanical base (Ormco Cor. Glendora Calif) lower central incisor orthodontic brackets were then bonded to porcelain with each adhesive according to the manufacturer's recomendations. The lower central incisor brackets were chosen since the bracket base is relatively flat and is best suited to bond to the flat porcelain surface. The excess resin was then removed with a sickle scaler and after 10 minutes, the samples were returned to the distilled water bath for 24 hours and then thermocycled. Each specimen under went 500 complete cycles with a temperature range of 4℃ to 60℃ and a dwell time of 30 seconds in each bath.[16] The specimens were then stored in distilled water at 37℃ for 7 days before mechanical testing. The material used in this study are shown in the table 1.

Shear force testing

The shear bond strength was tested with an universal testing machine (Shimadzu AG -1000E, Tokyo, Japan). Each bonded unit was placed in a jig that allowed a compressive force to be applied to the bond interface, including failing shear stress. A cross-head speed of 1 mm/Min was used. The load at failure was recorded and the stress at failure was calculated. The surface area of each bond was 0.09 cm^2.

After failure, a note was made of wether the failure mode was predominatly cohesive, adhesive or a combination thereof. The composite bracket bases were then boserved by scan electron microscope (SEM). (Figure 1)

Statistical analysis

The statistical analysis of the bond strength data used a one-way analysis of variance and the Student-Newman-Keuls multiple comparison that at the 5% level of significance.

Table 1. The materials used and their characteristics.

Agent	Composition	compomany
Unite	self cure resin	3M unitek
3M light cure	lignt cure resin	3M unitek
Composite bracket	Ploycarbonate	Ormco
Scotchprime	silane agent	3M unitek
Etch agent	9.6% HF solution	3M

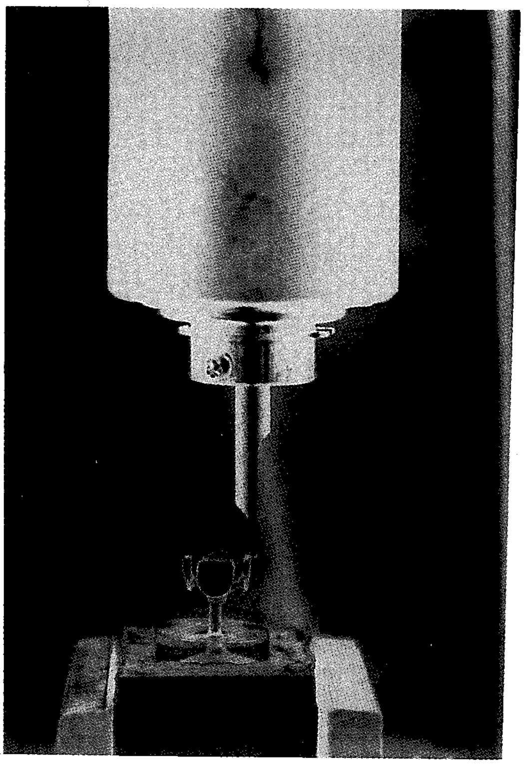

Figure 1. The tesing condition of the sample placed on the testing machine.

Result

The mean shear bond strengths, standard deviations and range in bond strengths for the four conditions are shown in Table 2. The group with self cure system plus acid etch produced the highest mean bond strength ($204.67\ kg/mm^2$). The group with light cure system plus without acid etch produced the lowest mean bond strength ($152.78\ kg/mm^2$).

Analysis of variance indicated a significant difference ($p<0.05$) in bond strength. The Student-Newman-Keuls multiple comparison test showed that light cure system without acid etch group had lowest bond strength. ($P<0.05$)(table 3)

Examination of the bond site failure at anatomic microscope with a magnification of 20X revealed that bond failure was both cohesive within the resin and adhesive at the resin/porcelain interface. In this study, most bond failure site, with chemical cure resin or light cure resin, occurs at the resin/porcelain interface. The SEM examination found that the mechanical junction portion were covered by the resin, the reisn portion were fractured with different morphology. (figure2)

Discussion

In this study, the acid etch procedure takes an important role on bonding strength. Hydrofluoric acid (HF) was used since it has been shown to increase the surface area of the porcelain by differentially dissoving the crystalline and glassy phase.[19,20] As we followed the Major method[2], that clinically acceptable bond strength with minimal porcelain

Table 2. The mean and standard deviation of different test condition analysed by ANOVA.

	Mean (Kg/cm^2)	Standard deviation
light cure + etching (1)	182.00	4.59
light cure − etching (2)	152.78	3.21
self cure + etching (3)	204.67	3.83
self cure − etching (4)	159.22	2.76

F=831.92 P=0.000

Table 3. The student-Neuman-Kuel test on different comparison.

	q	p<0.05
3 VS 2	63.404	YES
3 VS 4	55.535	YES
3 VS 1	27.700	YES
1 VS 2	35.704	YES
1 VS 4	27.838	YES
4 VS 2	7.869	YES

damage on debonding could be achieved with having to significantly alter the porcelain surface by mechanical means. In this study, HF acid was primarily used to acidify the alkaline layer of water at the surface and expectively achieve some etching effects as well.

In etching the enamel, there exist a reduction of phosphoric acid concentration from 37% to 20% effected a statistically significant decrease in shear bond strength.[21] The concentration of HF acid which level is best for bond strength on porcelain surface is needed further investigated. In etch time study on enamel, Kittipibul suggested that should be valid for any etching regiment between 15 and 60 seconds.[22] The most commonly used porcelain etchant is 9.6% HF acid in gel form applied for two to four minutes.[23]

The etchant creates microporosities on the porcelain surface that achieve a mechanical interlock with the composite resin. There are some suggestion on the concentration and time etching on the porcelain. Like application of a 1.23% acidulated phosphate fluoride (APF) gel for 10 minutes may provide equivalent bond strength to 9.6% HF acid applied for four minutes.[22] Zarrichson suggested when maximum bond strength to porcelain is desired, etching with an HF or APF gel is recommended.[22] Therefore, in this study with etched group do provide a strong shear bond strengths.

In Josephs and Rossouw study found that sites of failure among the ceramic brackets and the mesh-base brackets were mostly at enamel/resin interface when bonded with chemical-cure resin, and at resin/bracket interface when bonded with light cure resin.[24] For the plastic bracket, most bond failure has been found at enamel/resin interface. In bonded to enamel, the ceramic bracket and mesh-based bracket, bond failure site was found mostly at bracket/resin interface.[25,26] In this study, bond failure alwayse occurs at the resin/porcelain interface with either chemical cure resin or light cure resin. The result is simsilar with the

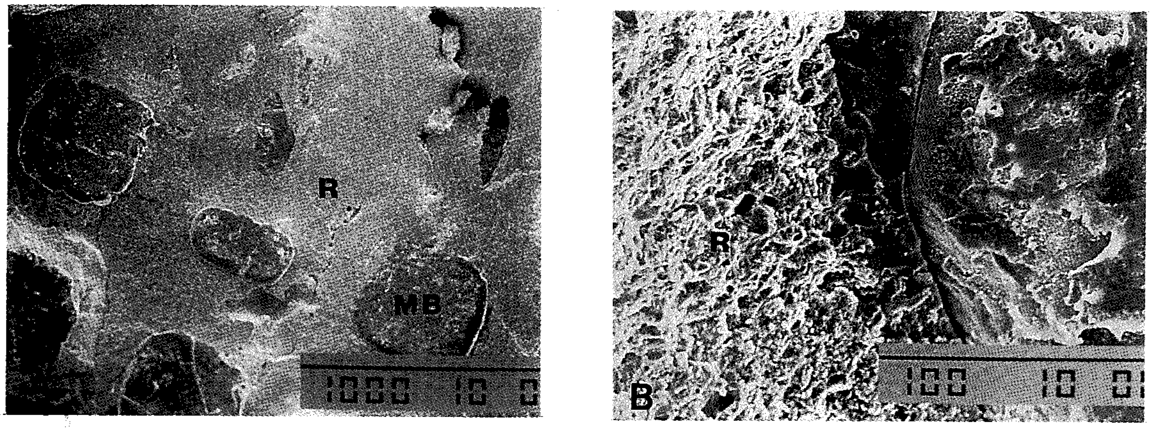

Figure 2. A. Scaning electron micrograph of base surface of brackets after shear test, showing the remaining adhesive(R) on bracket base. (SEM magnification 35X). B. High magnification of bracket base showing the roughening surface of the resin. (SEM magnification 500X)

failure site of plastic bracket bonded to the enamel. There are two basic types of dental resins currently in use for orthodontic bracket bonding. Resin of first type form linear polymers and second type may be polymerilized also by crosslinking into a three dimension network. In non-mixed adhesive bond strengths, bracket base morpholgic condition, bracket base treatment, filler loading and node of stress application will affect the bond strengths. In light cure adhesive bond strengths, maximum curing depth of light activated resin is dependent on the composition of the composite, the light source and the exposure time.(27) In this study there exist statistical differences between the light cure system and self cure system. The result needs further study to find what is the cause of the difference. In Viazis ceramic brackets bond strength study, found that there is no statistically significant difference between the mean shear bond strength of the new light cure orthodontic adhesive tested and the conventional chemically cure system.(28) In ceramic bracket, mechanical bonds (metal foil mesh and grooved based ceraminc bracket bases) fail mostly at the adhesive-bracket interface.(28) In this study the bracket base is the mechanical base either light cure adhesive or self cure adhesive used, the failure site of the adhesive were at resin/porcelian interface. The difference is proberbly caused by the differnt bracket materials. Porcelain surface after etching can produce the mechanical surface. The mechanical based bracket and etched porcelain are offered the same type of mechanical bonding sruface. The reason for failure site were seen between the resin/porcelain may be caused by the weakening adhesion between the resin and porcelain.

As Reynolds reported, 6 to 8 Mpa (58.8-78.4 Kg/mm^2) is the minimal shear bond strength that is required to withstand normal orthodontic force.(29) In this study the shear force of composite brackets bonded to porcelain surface were all larger than the normal orthodontic force needed. The surface of the porcelain after debonding did not see any fracture area. Therefor, even the difference is existed between the light cure adhesive and self cure adhesive paired with etch or not. The condition is suitable for the clinically used. Further study should focus on the different condition such as no roughening the porcealin, thermostress et al and to know what kind situation is best for the clinical.

Conclusion

For esthetic reason, the orthodontist need to understand every kind of cosmatic brackets bonding strength. From this study the mechanical based composite bracket bonded to the porcelain can provide ideal bond strength. We suggest that the clinican should follow porcelain bonding procedure. Then you can win an acceptable bonding strength.

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複合樹脂矯正貼片黏著於瓷牙表面之強度研究

高嘉澤　黃翠賢

由於黏著劑發展之進步，矯正貼片可與異於牙齒表面之界面如金屬和瓷等作結合。本研究之目的爲了解複合樹脂矯正貼片與瓷牙之黏著強度。按照瓷牙之裝作方式作出80顆瓷牙，將之分爲四組，每組20顆。在瓷牙表面分別作下面之矯正貼片黏著處理：第一組、去釉，氫氟酸，耦合劑，自動聚合樹脂。第二組、去釉，不加氫氟酸，耦合劑，自動聚合樹脂。第三組、去釉，氫氟酸，耦合劑，光聚合樹脂。第四組、去釉，不加氫氟酸，耦合劑，光聚合樹脂。經過500次冷熱交換處理，將所有樣本以每分鐘1㎜之速度作剪力強度測試。統計分析各組間之差異及電子顯微鏡觀察矯正貼片底部黏著情形。結果顯示黏著強度以第一組最高 ($p<0.05$)，各組間均存在差異，有酸處理組比沒有酸處理組強度較高。黏著劑斷裂位置大多在樹脂與瓷牙之界面。結語：由本研究之結果，實際各組之黏著強度均足夠用於矯正之操作，複合樹脂矯正貼片同其它貼片一樣可用於黏著於瓷牙表面。

關鍵字：複合樹脂矯正貼片、黏著強度、氫氟酸、瓷牙表面。

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