ORIGINAL ARTICLE

Comparison of Bond Strength and Mode of Fracture for Brackets Bonded to Porcelain Prepared with Hydrofloric Acid or Laser

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Background and aim: Laser ablation as an alternative method for etching porcelain has been proposed. However,previous studies have reported contrasting results. This study is designed to investigate techniques that could obtain maximum bond strength and also modes of their fracture. Materials and method: Fifty samples of porcelain fused to metal according to surface preparation were divided into five groups: 1.HF acid(9.6%) 2. HF acid+ silane 3. Co2 laser (2 w, 30 s) 4. Co2 laser+silane 5.removing the glazed layer with diamond bur (controls). After bonding orthodontic brackets and thermocycling process, the shear bond strength (SBS) measured with Instron. Results analyzed by one way ANOVA and Least Significant Difference ($p < 0.001$). pattern of debonding was investigated with light microscope and results were analyzed by Kruskall wallis and Mann-whitney ($p < 0.001$).

Results: results showed bond strength of Co2 laser (2 w) was clinically high although it was lower than HF acid samples, with better mode of fracture.

Conclusion: HF acid in combination with silane showed the highest shear bond strength value while irradiation of grouped pulse Co2 laser for 30 s in combination with silane could be an alternative for HF acid etching.

Key words: Co2 laser, HF acid, Porcelain, Shear bond strength

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Introduction

Increasing adult orthodontic demands, caused advances in restorative materials conditioning methods in order to achieve high bond strength. several techniques for preparing porcelain surfaces have been proposed, such as sandblasting, silica coating (1), chemical etching and laser etching(2).

Among available chemical etching agents, Hydrofloric acid (HF) followed by the application of a silane coupling agent is an accepted method to increase bond strength (2,3).the use of HF acid gel for ceramic etching is easy for chair side use with high bond strength but some disadvantages like enamel loss, nail and soft tissue burning, injuries to breathing and swallowing have been reported (4).

In addition to chemical etching, the ability of laser irradiation (Co2, Nd: YAG) for etching porcelain surfaces has been reported (2,4-9).

The results of previous studies about the laser treatment of dental ceramics have been controversial. These variations may be due to different types of lasers, different wavelength and irradiation energy of lasers.

Little studies compared bond strength of orthodontic brackets bonded to porcelain surface after laser or HF acid etching (4,6).

Therefore, this study investigates techniques that could obtain maximum bond strength and analyze the fracture mode of each technique for bonding to porcelain surfaces.

Material &Methods

Specimen Preparation

Fifty seven porcelain fused to metal specimens(feldespatic porcelain: super porcelain,EX-3,Japon) (Non precious alloy: supereme cast, Dent alloy Inc, USA) with diameter of 15 mm and height of 3 mm metal and 2 mm porcelain were prepared according to the lost wax technique recommended by manufacturer. Then specimens cleaned ultrasonically in ethanol and deionized water for 15 min.

In order to control the preparation area 4×4 mm rectangles were drawn in the center of each sample by aid of an aluminum foil.

Effective Laser Power on Porcelain Surface Determination:

Glazed layer of seven specimens in the determined region were removed by a diamond bur in 20 s.

They were then divided into one control and six experimental specimens. Untreated specimen served as control. One of the experimental specimens was treated with 9.6% HF acid (porcelain etches gel, Pulp Dent corporation water town, MA, USA) for 20 s. the other five experimental specimens were treated with different power settings (1,2, 4, 6, 8 watt) of Co2 laser (wavelength: 10000 nm, grouped pulse, on time: 20 ms, off time: 500 ms, group inverval: 0.5 s and 2 pulses in group).

The beam was aligned perpendicular to the specimens at a distance of 1 mm and moved in a sweeping fashion by hand during a 30 s exposure period over the determined area.

In order to determine suitable etched pattern comparable with HF acid, surface texture of irradiated samples were assessed with profilometer (Hommel Tester T 1000 , Hommel werke,Vs-schwening, Germany). Factors used for surface assessment were: Ra, Rzi, Rzj and Pc.

Total assessment showed that powers of 1,4,6,8 were not suitable for surface preparation because in these settings, either porosities were limited which did not increase the surface area significantly or they were so deep which inhibited surface wetting by resin and more bubbles formed in the resin-porcelain interface.

Results (Table .1) showed irradiated surface with 2 w laser power is similar to etching pattern of HF acid in the number and depth of porosities.

Test procedure

Fifty samples were assigned to one control and four experimental groups (n: 10/group).the porcelain treatments of the groups were as follows:

Group A. porcelain etched with 9.6 % HF acid for 20 s, then rinsing with water for 30 s and drying gently.

Group B. porcelain etched with 9.6% HF acid (20s) then water rinsing (30 s) and drying, then silanated for 60 s and dried gently.

Group C. porcelain irradiated with Co2 laser (2w, pulse moad, 20 ms on time, 500 ms off time, 0.5 s group distance) for 30 s.

Group D. porcelain irradiated with Co2 laser for 30 s then silanted for 60 s.

After HF acid or laser etching, the surface was covered with a small amount of adhesive primer (ORTHO ORGANIZER Inc, Carisbad, CA, USA) with a brush. A thin, uniform coating layer of covered the whole etched porcelain. The adhesive paste(ORTHO ORGANIZER Inc, carilsbad,CA, USA). With the adhesive applied, the brackets were placed on to the tooth surface immediately, adjusted to final position and pressed firmly. Excessive sealant and adhesive were removed from the periphery of the bracket base to keep the bond area of each tooth uniform.

According to the manufacturer instruction, we used a conventional light -curing unit (Demetron optilux 401, Danburg,conn) to shine each one for 30 s on the mesial and distal edges of the brackets. After storing the specimens in deionized water at 37°C for 24 h in incubator (digital incubator 01154, Behdad Industrial Co,Tehran,Iran) thermocycling process was done on the samples (1000 cycles of 30 s in 5°C, 30 s in intermediate medium and 30 s in 55°C) then the shear bond strength (SBS) tests were performed with a Hounsfield universal testing machine(H 25Ks,) at a crosshead speed of 0.5 mm/min. the shear bond test results were statistically analyzed by One Way Anova and then Least Significant Difference (LSD) ($p < 0.001$) (SPSS 11.0_for windows, Chicago, IL, USA).

To determine the fracture mode, the digital microscope calculated the area of adhesive remanant on the tooth and an SEM observed the fracture mode .

Fracture can occure in four modes as:

A. composite cohesive: fracture in composite layer

B. mixed: combination of fractures of adhesive and composite cohesive

C. adhesive:fracture in composite-porcelain interface

D. porcelain cohesive:fractures in porcelain

the results of mode of fracture were analyzed by Kruskal Wallis and then Mann-Whitney-U tests ($p < 0.001$).

Results

Bond strength

The SBS values of the different porcelain etching methods are shown in table.2. comparision of bond strength of group to group done with LSD analyze(table.3) . results stated that silane did not increase the bond strength significantly.

Fracture mode

Table.4 shows the failure sites in the four experimental groups. highest rate of composite cohesive fracture was in laser+silane group (the best form of fracture). Highest rate of porcelain cohesive fracture was in HF acid with silane group (the worst mode of fracture).

Discussion

This study showed the effectiveness of laser in porcelain etching although its SBS value was lower than HF acid conditioning. Bonding in orthodontics to enamel or other permanent restorative materials should be investigated in two points of bond strength value and pattern of fracture as the same importance(2,10). There is not an exact value for bond strength in orthodontics, but Reynold et al proposed 6-8 MPa as an adequate one (10-13).

Results showed that the mean SBS obtained from control group was 4 MPa which is lower than accepted value for bonding in orthodontics. Considering the results of this study and other studies, merely removing the glazed layer mechanically could not provide adequate bond strength(14).

Regardless of chemical or laser preparation silane did not increase the bond strength statistically significant ($P= 0.402$ in comparession of laser groups and 0.08 for acid groups). Some studies demonstrated that silane improved the chemical adhesion between ceramic and resin composite(1-3), but they did not include thermocycling after HF acid etching in their procedure. It is clear that thermocycling has a significant effect on bond strength value in comparession with studies in which no thermocycling was applied, decrease (2,3,12). Also different trade marks of silane, different

percentage, ph and kind of solvent makes differences. Matinlinha et al reported that Pulp Dent silane had the least effect on increasing bond strength value of luting cements to titanium surfaces in comparision to four other silane (15). Also, trakyalis et al demonstrated that increasing bond strength with Pulp Dent silane was significantly lesser than Reliance one(16).

Results of this study demonstrated that mean SBS values obtained by laser and laser+silane groups were in order 11.2 and 13.6 MPa, which were considerably higher than minimum of accepted for orthodontics. However,SBS values of laser groups were significantly lower than HF acid groups($p< 0.001$).

Our results were consistant with Aqua et al (6) study and others(4,7,8,17) but different from those of earlier studies which showed higher adhesion to porcelain after Er:YAG or Co2 laser ablation than HF acid etching (2,9). We considered different irradiation setting as the main reason . in our study, we first determined the laser energy settings according to the profilometer assessment. Therefore, the unfavorable condition like extensive subsurface fissuring reported by Martinez-Insua et al was not seen in this study (18). Because the bond strength is releated to the size of bonding area, it is important to control this area (19). In this experiment, we removed the excessive adhesive and resin outside the bracket. Also, the aluminium foil carefully controlled the etched and irradiated areas. This would reduce the variations and allow more uniform area.

According to the results, adhesive failures within laser samples were observed in the form of adhesive, like control group. We suspected that this was due to inhomogeneous and uneven surface produced by laser irradiation that contained many stress concentration sites.

Zacsion et al stated that after cohesive fracture in enamel or any permanent restorative materials like porcelain, adhesive fracture is the worst because of increased stresses and damages to enamel or porcelain surfaces(10,20). We supposed that silane act as an moderator between adhesive and porcelain layers which inhibited formation of cracks in low stresses and their propagation in high stresses. But this need more studies.

Tharmond et al reported that bond strength value more than 13 MPa increase the chance of cohesive porcelain fractures(21).

In our study, HF acid +silane samples obtained mean SBS of 16.4 MPa and also higher rate of cohesive failure. However, rate of other modes of fracture were higher than this mode.

Co2 laser ablation offer benefits over acid etching like reduction in clinical time, a reduced susceptibility to moisture during etching, adequate bond strength and better mode of fracture.

Conclusion

Within the limitation of this study, the following conclusions were drawn:

1.except diamond bur preparation of porcelain surface other applied techniques in this study showed an acceptable shear bond strength value.

2. Pulp Dent silane did not increase the bond strength significantly.

3. preparation of porcelain with HF acid in combination with silane showed the highest shear bond strength value.

4. the best and the worst mode of fracture was observed in laser+silane and HF+ silane groups, in order.

5. with regard to high shear bond strength value and cohesive fracture of composite, irradiation of grouped pulse Co2 laser for 30 s in combination with silane could be an alternative for HF acid etching.

References

1. Della Bona A, shen c &anusavice kj (2004) work of adhesion of resin on treated Lithia-based ceramic dental materials 20(4) 338-344.
2. B gokce, b ozpinar, m dundar, e comlekoglu,bh sen, ma gungor (2007) bond strengths of all-ceramics:acid vs laser etching 32(2) 173-178.
3. Ozcan m &vallittu pk (2003) effect of surface conditioning methods on the bond strength of

luting cement to ceramics dental materials 19(8) 725-731.

4. Poosti m,jahanbin a, mahdavi p, mehroush s. porcelain conditioning with Nd:YAG and Er; YAG laser for bracket bonding in orthodontics.laser in medical science. 2012;27(2):321-4.
5. Miserendino lj & pick rm(1995) lasers in dentistry quintessence pub co inc, Chicago, p174-185.
6. Akova t, yoldas o, toroglu ms,uysal h. porcelain surface treatment by laser for bracket-porcelain bonding. American journal of orthodontics and dentofacial orthopedics. 2005;128(5):630-7.
7. Li r, ren y, hanj.effects of pulsed Nd:YAG laser irradiation on shear bond strength of composite resin bonded to porcelain. West china journal of stomatology.2000;18(6):377-9.
8. Gokcelik a, ozel y, ozel e, arhun n, attar n, firatli s,et al.the influence of Er:YAG laser conditioning versus self-etching adhesives with acid etching on the shear bond strength of orthodontic brackets.photomedicine and laser surgery .2007; 25(6):508-12.
9. Ahrari f, heravi f, hosseini m.Co2 laser conditioning of porcelain surfaces for bonding metal orthodontic brackets. Lasers in medical science.2012:1-7.
10. Gillis I, redlich m. the effect of different porcelain conditioning techniques on shear bond strength of stainless steel brackets. American journal of orthodontics and dentofacial orthopedics.1998;114(4):387092.
11. Smith ga,mcinnes-ledoux p, ledoux wr, Weinberg r.orthodontic bonding to porcelain bond strength and refinishing. American journal of orthodontics and dentofacial orthopedics.1988;94(3):245-52.
12. Schmage p, nergiez I, Hermann w, ozcan m. influence of various surface-conditioning methods on the bond strength of metal brackets to ceramic surfaces. American journal of orthodontics and dentofacial orthopedics.2003; 123(5):540-6.
13. Panes dd,bailey dk, Thompson jy,pietz dm. orthodontic bonding to porcelain: a comparision of bonding systems. The journal of prosthetic dentistry. 2003:89(1):66-9.
14. Aoki a, sasaki km, watanabe h, ishkawa I. lasers in nonsurgical periodontal therapy. Periodontology 2000.2004;36(1):59-97.
15. Matinlinna jp,lassila lvj,vallittu pk. The effect of five silane coupling agents on the bond strength of a luting cement to a silica-coated titanium. Dental materials.2007;23(9):1173-80.
16. Trakyali g,malkondu o,kazazoglu e, arun t. effects of different silanes and acid concentrations on bond strength of brackets to porcelain surfaces. The European journal of orthodontics. 2009;31(4):402-6.
17. Filho am,Vieira lc,araujo e & monteiro junior s (2004) effect of different ceramic surface treatments on resin microtensile bond strength. Journal of prosthetics 13(1) 28-35.
18. Martinez-insua a, Dominguez lds,rivera fg,Santana-penin ua.differences in bonding to acid-etched or Er:YAG-laser-treated enamel and dentin surfaces. J prosthet dent.2000;84:280-288.
19. Oilo g. bond strength testing_what does it mean? Int dent j.1993;43:492-498.
20. Zachrisson yo, zachrisson bu, buyukyilmaz t. surface preparation for orthodontic bonding to porcelain. American journal of orthodontics and dentofacial orthopedics.1996;109(4):420-30.
21. Thurmond jw,barkmeier ww,wilwerding tm.effect of porcelain surface treatments on bond strengths of composite resin bonded to porcelain. The journal of prosthetic dentistry.1994;72(4):355-9.