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Tensile Bond Strength of Resin Composite to Er,Cr:YSGG Lased Dentin Bonded With Different Adhesive Systems

Ula A. Fathi
BDS.
Conservative Dentistry Department
College of Dentistry, University of Mosul

Ma'an M. Nayif
BDS, MSc, PhD. (Lect.)
Conservative Dentistry Department
College of Dentistry, University of Mosul

الخلاصة

الاهـــداف: بمـا أن لقـوة الرابطـة القابلـة للشـد اهميـة في تقييـم نجـاح الحشـوات ذات اللواصـق, لذلـك فـان الهـدف مـن هـذه الدراسـة هـو تقييـم قـوة الرابطـة القابلـة للشـد الحاصـل في حشـوات الراتنـج المركـب مـع العـاج المعامـل باسـتخدام الليـزر (Er, Cr: YSGG والملصقـة بثـلاث انـواع مـن نظـم اللصـق. **المـواد و طرائـق العمـل** : تم اختيـار (١٨) سـنا مـن اسـنان العقـل المقلوعـة.وتم ازالـة المينـا الانطباقـي. ثم عـولج السـطح المكشـوف بأسـتخدام جهـاز الليـزر. قسـمت العينـات عشـوائيا الى ثلاثـة مجاميـع اعتمـادا علـى نـوع المـادة اللاصقـة (لـكل مجموعـة منهـا ٦ اسـنان). المجموعـة الاولى :تمـت معالجـة العـاج بلاصـق كلـي التخريـش (Adper single bond, 3M ESPE). المجموعـة الثانيـة: تمـت معالجـة العـاج بلاصـق ذاتي التخريـش ذو المرحلـة الواحـدة (Adper easy one, 3M ESPE) . المجموعـة الثالثـة: تمـت معالجـة الحفـرة بلاصـق ذاتي التخريـش ذو المرحلتـين (Clearfil SE bond, Kurary).تم تثبيـت انبوب بلاسـتيكي شـفاف و ملـئ بالراتنـج المركـب الهجـين, ثم ادخـل لولـب معـدني صغـير مـع حلقـة رأس في الاضافـة الأخـيرة و العينـات خزنـت في المـاء المقطـر عنـد (37°C) لمـدة (٢٤) سـاعة. بعدهـا تم قيـاس القـوة الرابطـة القابلـة للشـد. **النتائـج**: لوحـظ وجـود اختـلاف معنوي في القـوة الرابطـة القابلـة للشـد بـين المجموعـات ($p < 0.05$).الحشـوات ذات التخريـش الكلـي اظهـرت قيمـة القـوة الرابطة القابلة للشـد اعلـى مـن الحشـوات ذات اللاصـق ذاتي التخريـش ذو المرحلتـين و الحشـوات ذات اللاصـق ذاتي التخريـش ذو المرحلـة الواحـدة .ولوحـظ عـدم وجـود اختـلاف معنـوي في القـوة الرابطـة القابلـة للشـد بـين الحشـوات ذات اللاصـق ذاتي التخريـش ذو المرحلتـين و الحشـوات ذات اللاصـق ذاتي التخريـش ذو المرحلـة الواحـدة ($P>0.05$). **الاسـتنتاجات** : القـوة الرابطـة القابلـة للشـد في حشـوات الراتنـج المركـب الهجـين تتأثـر بنـوع اللاصـق الحشـوات ذات كلـي التخريـش اظهـرت قيمـة القـوة الرابطـة القابلـة للشـد اعلـى مـن الحشـوات ذات اللاصـق ذاتي التخريـش ذو المرحلتـين و الحشـوات ذات اللاصـق ذاتي التخريـش ذو المرحلـة الواحـدة.

ABSTRACT

Aims: Tensile bond is important for assessing the success of adhesive restorative materials. The aim of this study is to evaluate the tensile bond strength of resin composite restoration to Er,Cr:YSGG lased dentin bonded with three types of adhesive systems. **MATERIALS AND METHODS:** Occlusal enamel of eighteen molars samples was removed to expose the underlining dentine. Er,Cr:YSGG laser irradiation was performed to central dentin. Samples were assigned randomly to three groups (N = 6): Group I: dentin was treated total etch adhesive (Adper single bond, 3M ESPE); Group II: treated with all in one self—etch adhesive (Adper easy one, 3M ESPE); Group III: treated with two step self—etch adhesive (Clearfil SE bond, Kurary). A translucent plastic tube was fixed and filled incrementally with hybrid resin then small metal screw with ring head was embedded in last increment. Samples were stored in distilled water at 37°C for 24 hours. Tensile bond strength was measuredd using universal testing machine (Digital Force Gauge IMADA CO., LTD, Japan), the failure mode was evaluated. Then statistical analysis was done include descriptive, one way analysis of variance test, and Post Hoc tests. **RESULTS:** A significant differences in tensile bond strength were observed among groups ($p < 0.05$). Total etch adhesive bonded demonstrate significantly higher tensile bond strength value than one step self–etch and two step self–etch adhesives ($p < 0.05$). No significant differences were observed between one step self–etch and two step self–etch adhesives ($P>0.05$). **CONCLUSION:** The tensile bond strength of resin composite to Er,Cr:YSGG lased dentin was influenced by adhesive type. Total etch adhesive bonded had higher tensile bond strength than one step and two steps self–etch adhesives.
Key words: Adhesive systems, Er,Cr:YSGG laser, resin composite, tensile bond.

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INTRODUCTION

Development in dentistry has been focused on using lasers for cavity preparation due to many advantages like the absence of pressure, vibration, noise, or significant pain,[1] and also allows selective removal of carious tooth structure.[2] The Er,Cr:YSGG laser (emitting at a wavelength of 2.79 μm), it is absorbed strongly by both water and hydroxyapatite.[3] Although erbium laser devices considered the most efficient and safe systems for cavity preparation,[4] it may

cause different surface change, removing the smear layer, exposing dentinal tubules and creating a surface with a different characteristics in comparison to surface treated with conventional bur.[5]

Previous studies reported that irregularities and the crater-shaped appearance of ablated dentin was comparable to the dentine surface after acid etching, which might promote micromechanical interlocking between dental restorative materials and the tooth surface.[6,7] Reports on the bond strengths of composite resin to a tooth substrate prepared by a laser are often confusing and contradictory. Some studies reported higher bond strengths to laser-prepared dentin.[6,8] Other studies indicated a significant deterioration of bond strength[7,9,10].

Currently varies dentin adhesive systems are used in dental practice: Some utilize phosphoric acid to remove the smear layer, followed by adhesive material. This bonding mechanism eliminate smear layer on dentin and form micromechanical interlocking of the resin within the exposed collagen fibril. [11] Self-etching is another adhesives that perform substrate etching and infiltration simultaneously. It provides resin infiltration beyond the smear-covered surface into the underlying dentin matrix. Therefore, a hybrid layer is formed with the smear layer incorporated to it[12]. The self-etching systems may be provided with two or one bottle. The two steps system the primers and acidic monomer mixed together then followed by adhesive application. One-step self-etch adhesives include all components in one bottle to reduce clinical application time and lessen the complexity of the application technique.[13]

The method of surface treatment as well as the choice of bonding agent might influence the development of a hybrid layer. It is important to accentuate that adhesive systems are initially established to be applied onto tooth surfaces treated by conventional techniques. Thus, in view of the widespread of laser particularly erbium family, it is essential to examine the effect of laser ablation on adhesion bond strength.

The aims of study is to assess the tensile bond strength of three currently used adhesive system (total-etch and self-etching one and two steps) to Er,Cr:YSGG laser-irradiated dentin. The null hypothesis tested is that there is no difference between the three adhesive systems to laser-ablated dentin.

MATERIALS AND METHODS

Sample collection and preparation:

Eighteen caries free freshly extracted human third molars were collected from patients between 18 and 25 years. Teeth were cleaned with hand scaling, stored in water and used within one week. Occlusal enamel of samples was removed until expose the underlining occlusal dentine using orthodontic trimmer with water cooling. Occlusal surfaces were polished using 400 grit water proof polishing paper under water for (2mint) for each sample. This procedure provide flat glossy dentine surface with standardized smear layer. Occlusal surfaces were examined under magnification lens (5X) to ensure that there is no remaining enamel over the dentine. The central dentin area was demarcated with adhesive tape with 4mm diameter hole.

Laser irradiation of dentin surface:

Sample was fixed to surveyor and laser handpiece was attached to insure fixation of laser tip distance, angle and movement Figure (1).

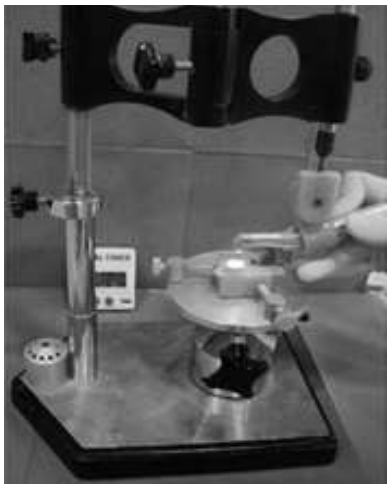

Figure (1): Sample and Er,Cr:YSGG laser handpiece fixed on the surveyor.

Then the exposed surface of the dentine were treated with Er,Cr:YSGG (Waterlase iplus, BIOLASETechnology, USA). The following parameter (2780 μm wavelength, a pulse duration 140 - 200 μs, a pulse repetition rate of 20 pulses per second (20 Hz), 2.75 W power , 80% air spray and 70% water spray) was used this parameter follow manufacture recommendation indicated for cavity preparation with slight modification . Laser energy was delivered through fiber-optic system to tip (MZ6) of 0.6 mm diameter and 6 mm long. A non-contact mode was applied during preparation so the irradiation distance was fixed between the fiber optic tip and the tooth surface at 1mm utilizing the surveyor. In order to assure uniform exposure of the dentin surface bonding area, a sweeping movement of the laser tip at constant speed in alternative sequence within area of 4mm. The total time applied for each sample was twenty seconds.

Bonding procedure:

Samples were randomly divided into three groups according to the type of bonding systems. The bonding systems selected for this study represent the most commonly used and efficient systems for resin composite restorations: Total etch adhesive system (Adper single bond 2, 3M ESPE); one step self-etch adhesive system (Adper easy one, 3M ESPE); two step self-etch adhesive system (Clearfil SE Bond, Kuraray, Tokyo, Japan).

Group A: Dentin was treated with total etch adhesive system.

Group B: Dentin was treated with one step self-etch adhesive system

Group C: Dentin was treated with two step self-etch adhesive system.

All adhesives were applied and light cured according to manufacture instructions. A translucent plastic tube with 4mm internal diameter and 4 mm height was fixed onto central region of dentin surface using sticky wax Figure (2). Hybrid resin composite (Filtek Z-250, 3M ESPE) was incrementally applied onto plastic tube up to 2mm and cured for 20 sec. from buccal and lingual direction using Ivoclarvivadent (LEDition) light-curing unit with a light output of 500 mW/cm². The last increment was applied then small metal screw with ring head was embedded in perpendicular position followed by curing the composite as in first increment Figure (2). The plastic tube surrounding the composite was carefully removed with aids of surgical blade. Samples were stored in distilled water at 37°C for 24 hours.

Figure (2): translucent plastic tube fixed with sticky wax and filled with composite with screw embedding in it.

Tensile bond strength test:

Sample crowns were gripped by clamp of universal testing machine (Digital Force Gauge IMADA CO., LTD, Japan) and the ring was connected to the upper hook of the device. A tensile force was applied at a crosshead speed of 0.5 mm/minute until debonding Figure (3). The mode of failure was determined at 20 X magnification using a Stereomicroscope (Motic, Italy). Mode of failure was divided either adhesive when the dentin exposed or cohesive failure when composite or adhesive detected or mixed failure when combination detected.

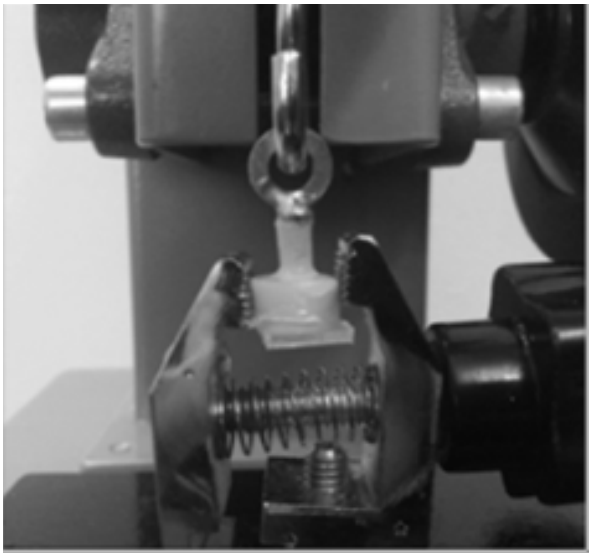

Figure (3): sample with small metal screw with ring head attached to universal testing machine (Digital Force Gauge IMADA CO., LTD, Japan)

Statistical analysis:

A statistical analysis was performed using Statistical Package for the Social Sciences (SPSS 13.0, SPSS Inc. USA).

1. Descriptive statistics including mean, standard deviation (SD) value.
2. One way analysis of variance test used to test significance in tensile bond strength among groups.
3. Turkey's Post Hoc test was used to determine the difference in tensile bond strength among groups.

All the statistical tests were computed at 5% significant level.

RESULTS

Mean and standard deviation (SD) of tensile bond strength are shown in Table (1).

Table (1) : means and standard deviations of the differences in working lengths of each instrument system

Type of adhesives	Total etch adhesive	One step self–etch adhesive	Two step self–etch adhesive
Mean	60.33	34.66	30.83
SD	14.61	14.47	9.45

One way analysis of variance test show a significant difference among the groups (P<0.05) Table (2). Post Hoc tests comparison of tensile bond strength between adhesives show that there was significant difference in tensile bond strength between total etch and one step self–etch adhesive and between total etch and two step self–etch adhesive (P<0.05).

Table (2): One way analysis of variance test of tensile bond strength among different adhesives

	Sum of squares	df	Mean square	F	Sig.
Between groups	3087.444	2	1543.722	9.040	
Within groups	2561.500	15	170.767		.003
Total	5648.944	17			

No differences was observed between one and two step self–etch adhesives (P>0.05). The composite bonded with total etch show higher tensile bond strength than composite bonded with one step or two step self–etch adhesive. While those bonded with one step self–etch adhesive demonstrate no significant differences in tensile bond strength than composite bonded to two steps self–etch adhesive. Total etch adhesive show

mostly cohesive failure while one and two step self–etch adhesives show mostly adhesive and mixed failure.

DISCUSSION

Various factors can affect the tensile bond strength of composite resin to dentin, such as type of adhesive system, presence or absence of smear layer and morphological changes of dentin.[14] Therefore this study has been designed to evaluate the bond strength of adhesive resin composite restoration utilizing the most commonly used adhesive systems in dental practice.

In comparison to bur, most dental laser irradiations dental surfaces are chemically modified with loss of carbonate, formation of new hydroxyapatite like crystals, and consequently more acid resistant surfaces[15]. In particular Hossain et al. asserted that acid resistance can be promoted by Er,Cr:YSGG laser irradiation[16].

Accordingly it appears necessary to study behavior of adhesive restoration on dentin structure after treatment with laser. Cardoso et al. concluding that irregularities on the lased dentin surface may decrease the bond strength due to a non-uniform thickness of the adhesive layer.[17,18]

Also the increased of temperature produced by laser modified the surface, in which the collagen network completely melted and vaporized. Thus the denatured collagen fibrils are fused together and poorly attached to the underlying unaffected dentin, preventing formation of a regular hybrid layer.[19,20] To overcome these problems, mechanical or chemical removing of laser modified layer has been suggested.[21] It has been found that adjunctive use of phosphoric acid following water rinsing eliminated the laser modified layer and thus authers recommended longer etching time to obtain higher bond strength[22].

The result of this study demonstrated higher tensile bond strength of resin composite to dentin when treated with total etch adhesive in comparison to self–etch regardless of application step (one or two). These results agree with other studies, Ramos et al.[23] found that Clearfil SE Bond self–etching primer appeared to be the more affected by the laser ablation on the dentin substrate, than total–etch Single Bond resulting in the weakest adhesion. Also, De Munck et al. 2002found self–etching primer adhesive system yielded the lowest bond strength in the Er:YAG–lased subgroups,[24] Son J. et al. suggest three step total–etching system seems preferable to mild self–etching system when applied on laser irradiated dentin in the hypersensitivity mode and increase of etching time for three step total–etching system would be beneficial.[25]

The results of this study suggest that Adper single bond adhesive requires previous acid etching with strong phosphoric acid 35% (pH= 0.6) that may remove most of the superficial layers of the irradiated dentin so may increase the tensile bond strength. On other hands, two steps Clearfil SE Bond and one step Adper easy one self–etch adhesives have weak acid combined with the primers (PH=1.9 and 2 respectively), could not remove the more acid resistance superficial layers of the irradiated dentin completely so cannot modify the surface to promote adhesive penetration result function impairment .

These result comport to Aranha et al. 2007 analysis of interfacial micromorphology of Er,Cr:YSGG lased dentin bond with different adhesive system as they found that the Clearfil SE Bond adhesive system after Er,Cr:YSGG laser irradiation did not show hybrid layer formation. While Single Bond self –etch adhesive system shows a thin hybrid layer formation. Under higher magnification, the qualitative analysis of the dentin–resin interface demonstrated the presence of gaps in dentin, resin interface when the self–etching primers and the one–bottle adhesive systems were used which indicate improper penetration of the adhesive that might negatively affect bond strength[26].

Van Meerbeek et al., 2010 suggested that there was as a strong correlation between the value of bond strength and the failure mode: the higher the bond strength, the higher the rate of cohesive failure[27]. Failure mode analysis of our study revealed that total etch adhesive shows predominantly cohesive failure at resin dentin interface which was in correlation with higher bond strength value for such type of adhesive system. However for other systems evaluated in this study namely one and two step self –etch adhesives the mode of failure shows adhesive and mixed failure pattern with exposed dentin surfaces.

In conclusion when dentin prepared with Er,Cr:YSGG laser the tensile bond strength of resin composite was influenced by adhesive type . Total etch adhesive system demonstrated higher tensile bond strength in comparison to self –etch adhesive. Also it can be concluded that two step adhesive

systems didn't show better bond strength than one step adhesive systems.

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