

The Influence of Er: YAG Laser, Aluminum oxide and diamond bur on surface treatment of Aged Composite Resin to Repair Restoration.

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الخلاصة

الأهداف: لتقييم تأثير Er: YAG ليزر ، وأكسيد الألمنيوم ، برينة الماس كعلاج للسطح على قوة الربط ألتزلاقي لحشوه الأسنان البيضاء القديمة المرمة . **المواد وطريقه العمل:** أعد ستون قالب تفلون (٤ملم * ٢ ملم) من تترك (ر) سيرم و قسمت العينات عشوائيا إلى ست مجاميع رئيسيه عُوملت ب العلاجات السطحية التالية: الأولى بدون معاملة (قياسيه) ، والمجاميع من الثانية الى الرابعة عُوملت بكميات طاقة ليزنه مختلفه (٤٠ ، ٦٠ ، ٨٠ ، ١٠٠) ملي جول ليزر بالتوالي بتدد ٢هرتز، الخامسة ب برينة الماس ، و السادسة ب أكسيد الألمنيوم. ثم قسمت كل من المجاميع الست إلى مجموعتين فرعيتين : الأولى بدون معاملة (قياسيه) ، والثانية عُوملت ب٣٧٪ من حامض الفوسفوريك ثم وضعت المادة اللاصقة على السطح المعامل ووضع الجزء الثاني من قالب تفلون (٤ملم * ١ملم) فوق القالب الأول وملاً بمادة ألتترك (ن) سيرم. اختبرت العينات بماكينة الاختبار العالمية. **النتائج :** اختلافات معنوية لجميع المتغيرات. أظهرت السطوح ألمعامله ب ٦٠ و ٤٠ ملي جول ليزر أعلى قوة ربط اترلاقي (٤٥,٢٤ ، ٤٥,٠٣ ميغاباسكال على التوالي) ، بينما السطوح ألمعامله ب أكسيد الألمنيوم كان لها اقل قوة ربط (٣٢,٤٨ ميغاباسكال). أظهر حامض الفوسفوريك أعلى قوة ربط (٤٠,٤٧ ميغاباسكال) مقارنة بالمجموعة القياسية (بدون معاملة) (٣١,٦٢ ميغاباسكال). **الاستنتاجات:** استخدام Er: YAG ليزر يحسن من قوة الربط لحشوه الأسنان البيضاء المرمة مقارنة مع برينة الماس و أكسيد الألمنيوم بينما استخدام حامض الفوسفوريك يعزز من قوة التصاق مثل هذه الحشوات .

ABSTRACT

Aims: Aim of this study is to investigate the effect of Er: YAG Laser, the sand blasted with aluminum oxide and wearing with diamond bur as a surface treatment to the bond strength of repaired composite resin after aged. **Materials and Methods:** Sixty Teflon mold (4mm×2mm), of Tetric® Ceram prepared. The specimens were randomly separated into six groups and undergo the following surface treatments: G1 no treatment (control), G2-G4 treated with a different amount of laser energy (40, 60, 80 mJ Er: YAG laser respectively) under a 2Hz frequency, G5 wearing with diamond bur, and G6 sandblasted with 50µm aluminum oxide. All 6 groups divided into two subgroups, 1st control, 2ed etched with 37 % phosphoric acid. Bonding material was applied and the second split of Teflon mold (4mm×1mm) placed onto the prepared specimen, filled with Tetric N-Ceram. The shear test was done using the Universal testing machine. **Results:** Significant differences of all variables, laser 60,40mj surface treatment displayed superior shear strength (45.24, 45.03 MPa respectively), aluminum oxide showed low shear value (32.48 MPa). Phosphoric acid showed the highest shear value (40.47 MPa) in compare to the control one (31.62 MPa). **Conclusions:** Using of Er:YAG laser improve the shear value of repaired composite in comparing with a diamond bur and aluminum oxide. Conditioning aged composite surface with a phosphoric acid enhancing its adhesive result.

Keywords: Er: YAG Laser, Aluminum oxide air abrasion, and Composite repair.

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INTRODUCTION

The rising patient demand of esthetic dental restorations coupled with concerns about the toxicity of amalgam that has markedly increased the use of composites. The composite resin is highly challenged over time by degradation due the effect of

pH, salivary enzymes and wet environment^(1, 2). This degradation promotes superficial loss, cohesive fractures, color changes and restoration staining^(3, 4).

Despite some recent improvements, their technique sensitivity leads to numerous failures in the clinical setting, especially when they are used in posterior

teeth. The repair of composites that exhibit small fractures, staining, or wear may be a viable and less costly alternative to their complete replacement and would cause less pulpal trauma⁽⁵⁾. The composite associated to acid conditioning and the adhesive systems constitute a restorative system that has been revolutionizing dentistry, modifying the concepts of cavity preparation and allowing a major conservation of the remaining healthy dental structure^(1, 2). But some factors as the preparation of the surface to be repaired, the composite viscosity to be used, surface porosity, the kind of adhesive system applied and the time when this restoration was made influence upon the adhesion strength of the repair interface⁽⁶⁾.

A large variety of superficial treatments to old resin restorations have been proposed to maximize composite repair. The utilization of diamond burs to remove old restorations is the most used method. Even so, this technique reveals some disadvantages once it is not selective to remove the material. The cavity preparation with rotary instruments is painful for the patient, requiring anesthesia in most cases⁽⁷⁾.

The sandblasting of aluminum oxide particles under high pressure through a small aperture has been used in Dentistry. The aluminum oxide particles produce irregular surfaces, which increase the adhesion area that can increase the interaction between the both surfaces composite⁽⁸⁾.

The laser has been widely used in many specialties of dentistry^(9, 10). The Er: YAG laser has a wavelength of 2940 nm, which is absorbed by the water and also by the hydroxyapatite present on the enamel and dentin. This laser produces heat, lead-

ing to the liberation of hydroxyl groups from hydroxyapatite⁽¹¹⁾, provoking an instantaneous evaporation of the water layer that surrounds the apatite crystals and of the water present in them. As the water evaporates, it increases the pressure inside the tissues, provoking micro explosions⁽¹²⁾. This process is known as ablation⁽¹³⁾. Most of the energy is consumed in this process and the residues diffuse into the interior of the irradiated tissue, without causing an excessive increase in temperature in the adjacent tissues⁽¹⁴⁾. The effect of this treatment over surfaces does not damage the adhesion, when the total conditioning technique with phosphoric acid is used. Therefore, adjacent surfaces to the repaired restorations would not be negatively affected when utilizing the Er: YAG^(12, 14). But when the composite restorations surrounded by enamel, certain selectivity for the ablation of composites were shown, as enamel ablation is slower than ablation of composites. However, this selectivity is compromised in dentin because of a higher ablation rate of dentin compared to some composite brands, due to the higher water content of dentin⁽¹⁵⁾. Aim of our study to investigate the effect of different output energy of Er: YAG Laser, the sand blasted with aluminum oxide and wearing with diamond bur as a surface treatment on the bond strength of repaired aged composite resin.

MATERIALS AND METHODS

The materials used in this study listed in (Table 1). Sixty specimens of a light cured Tetric[®] Ceram composite, prepared using a Teflon mold (4mm *2mm) (Figure 1 a, b and c).

Table (1): MATERIALS USED

Material	Batch No.	Manufacturer
Tetric [®] Ceram, Dental Restorative	K00653	Ivoclar vivadent
Total Etch ,37% phosphoric acid	K48227	Ivoclar vivadent
Tgflow,Flowable Light Cure Composite	0510	Technical & General LTD, London, UK.
Tetric N-Ceram	K09686	Ivoclar vivadent

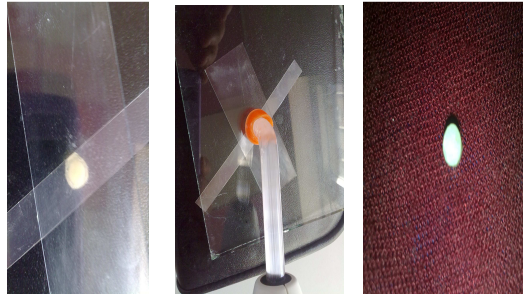


Figure (1): steps for preparing sample

The mold inserted on a glass slide, filled with a Tetric[®] Ceram using an incremental technique with a plastic instrument, covered with Mylar strip and glass slide to produce a smooth surface and facilitate curing, cured with visible light source (Ivoclar vivadent. LED itian) for 40s from the top of the specimen with a standard light at $560\text{mw}/\text{cm}^2$ assessed with a radiometer every 5 restorations. The samples were stored in distilled water at 37°C for 24h, thermo-cycled with the objective to reproduce, in vitro, thermal changes that occur clinically. Many authors have used this procedure in order to simulate material aging^(7, 16, 17). Thermo-cycled for 300 cycles at temperature ranging from $5\pm 2^\circ\text{C}$ to $55\pm 2^\circ\text{C}$; each cycle lasted for 45s with a dwell time of 15s, in each path, and 15s intervals between paths.

The Specimens were randomly assigned into six groups according to the type of the surface treatment as follow (n

=10):

1- The top surface of Tetric[®] Ceram was remaining intact (control).

2- The surface treated with the Er: YAG laser (KaVo KEY Laser 3, class 4, “1243”, KaVo Dental GmbH Vertriebsgesellschaft) (Figure 2). “This unit operates in the scheme with microsecond pulse duration between 200 and 450 μs , emitting a wavelength of 2.94 μm . a pulse frequency: 1-25 Hz, pulse energy: 40-600 mJ. Pilot beam: 655 nm/1 mw. It presents a delivery system with an articulated arm, contra-angle handpiece and non-contact bundle with a spot area of around 0.466 mm^2 ”. It was used a 2 Hz frequency, laser was focalized(12 mm distance from target surface), the pulse energy applied was 40mJ with water jet, Laser beam incidence perpendicular to resin surface (5 spot for each sample with 1mm distance between each spot) (Figure 3).



Figure(2): KaVo KEY Laser 3.

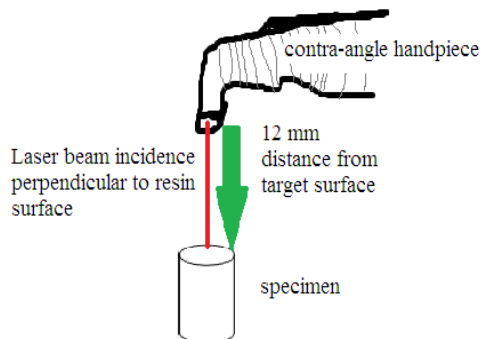


Figure (3): diagram represent operated Surface with KaVo KEY Laser 3 contra-angle hand piece

3. Like group 2 the surface treated with the Er: YAG laser 60, 80 mJ respectively.
4. The composite surfaces were roughened in (5) strokes with a diamond bur (No: 10543M, **tg** bur, LOT 0205, Ø 0510, Technical & General Ltd. London, United Kingdom). A new bur was used for each 5 samples.

5. The composite surface air-abrade with 50µm aluminum oxide particles using a MICROBLASTER (bio.art Rua Teotônio Vileia, 120- Jd. Tangará-CEP 13568-000- São Carios- SP- Brasil.) operating at a 5mm distance and 90° to surface for 5s, washed with a distilled water and dried (Figure 4).

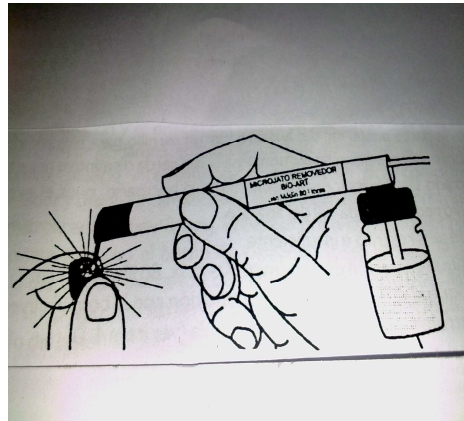


Figure (4): diagram represent operated Surface with micro blaster

The Specimens of each group (1- 6), were farther subdivided in two subgroups (A1 and A2), (n=5) and immediately further processed. Group (A1), the surface of specimens was remaining intact (control). Group (A2), the surfaces treated with 37% phosphoric acid for (15s), washed with water for (10s). Excess water removed with cotton balls, leaving the surface slightly humid. After drying procedure, adhesive technology, (**tg**flow Flowable Composite), " the use of a flowable composite resin has been shown to be a reliable method of repair for composite restorations due to its superior flowability"⁽¹⁸⁾, applied in a thin layer on the top surface of the composite using a micro-brush, gently

air-thinned under compressed air and cured for 20s. Immediately the second split of Teflon mold (4mm * 1mm) placed on to the prepared specimen, filled with Tetric N-Ceram, and cured for 40s. After curing, specimens were removed from Teflon molds, stored in distilled water at 37°C for 24h.

The shear bond strength between the light cured Tetric[®] Ceram composite and the repaired restoration measured by using Universal Testing Machine (Soil Test Co. Inc., ILL. USA) (Figure 5 a, b, and c) with a Knife edge head placed at the interface between the old and repaired composite at a cross head speed of 0.5mm/min.

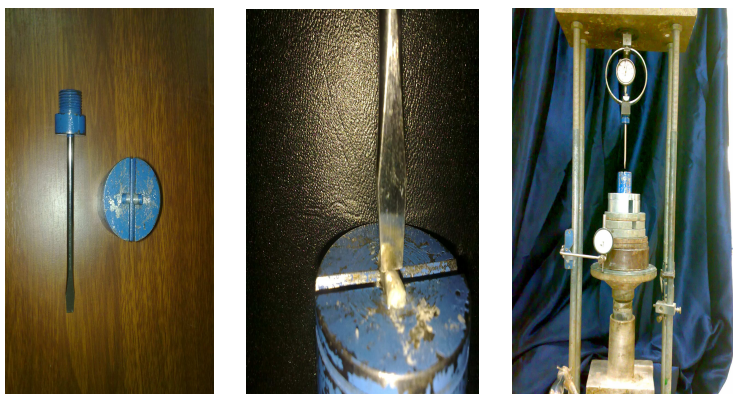


Figure (5): Testing the sample by Universal Testing Machine (Soil Test Co. Inc., ILL. USA)

Data were tabulated and statistically analyzed. They were analyzed using analysis of variance (ANOVA) followed by Duncan's Multiple Range Test at 1% level of significance to indicate if there were any statistical difference in shear bond strength

of all groups.

RESULTS

Means and standard deviations of shear bond strength (MPa) of variables are shown in Table (2).

Table (2): Means and standard deviations of Surface treatment, Adhesives and Restorative Material

Surface treatment	Acid Etching	
	Control	PH
Control	26.19 ± 8.42	36.46 ± 14.77
laser 40mj	43.06 ± 8.35	46.99 ± 8.74
laser 60mj	44.38 ± 4.68	46.12 ± 4.73
laser 80 mj	32.57 ± 10.41	34.32 ± 10.39
Diamond bur	31.26 ± 10.75	42.85 ± 6.76
AL ₂ O ₃	12.24 ± 3.74	36.07 ± 3.46

Mj: mill jowl energy; AL₂O₃: Aluminum oxide air abrasive; PH: Phosphoric acid.

Mean square analysis at level 1% listed in Table (3) showed highly significant differ-

ences for all variables.

Table (3): Mean square analysis for Surface treatment, and Acid Etching

	S.O.V.	d.f.	M.S.
Surface treatment		5	673.81**
Acid etching		1	1175.71**
Interaction between surface treatment and acid etching		5	179.42*
Error		48	73.56

** Indicated highly significant differences at 1% level, * indicated significant differences at 5% level, d.f.: Degree of freedom; M.S.: Mean square; S.O.V.: Source of variance.

The interaction between variable was significant at 5% level. Duncan's New Multiple Range Test to revealed the differenc-

es in shear bond strength value of surface treatment, and acid etching are shown in Table (4).

Table (4): Duncan's New Multiple Range Test for variables

Surface Treatment	Acid Etching		Means of Surface Treatment
	Control	PH	
Control	26.19 ^e	36.46 ^{a-e}	31.33 ^{bc}
laser 40mj	43.06 ^{a-d}	46.99 ^a	45.03 ^a
laser 60mj	44.38 ^{a-c}	46.13 ^{ab}	45.24 ^a
laser 80 mj	32.57 ^{c-e}	34.32 ^{b-e}	33.45 ^b
Diamond bur	31.26 ^{de}	42.85 ^{a-d}	37.05 ^b
AL ₂ O ₃	12.24 ^f	36.07 ^{a-e}	24.16 ^c
Means of Acid Etchings	31.62 ^b	40.47 ^a	

Different letters indicate significant differences. Mj: mill jowl energy; AL₂O₃: Aluminum oxide air abrasive; PH: Phosphoric acid.

For the surface treatment groups the laser 60mj and 40mj surface treatment displays superior shear bond strength (45.24, 45.03 MPa respectively) than

treating the surface with aluminum oxide that displayed low value (24.16 MPa) (Figure 6).

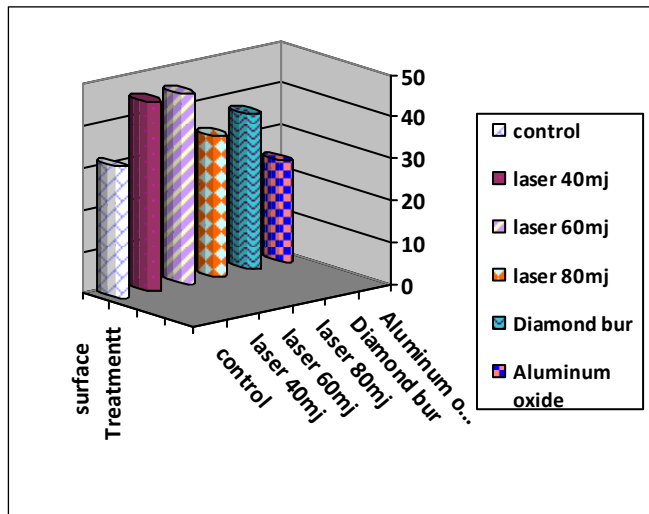


Figure (6): a histogram representing the mean of shear bond strength of the surface treatment groups

For the acid etching the using of 37 % phosphoric acid showed the highest

shear value (40.47 MPa) in compare to the control one (31.62 MPa) (Figure 7).

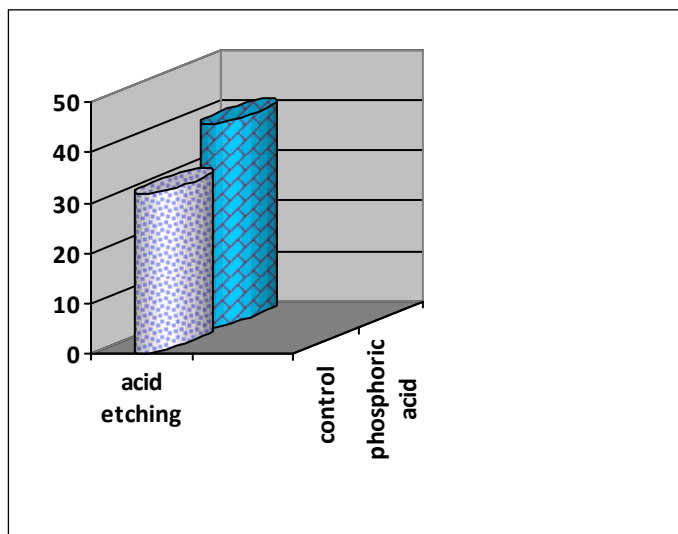


Figure (7): a histogram representing the mean of Shear bond strength of the acid etching groups

For the interaction between the surface treatment and the acid etching showed a superior shear value when laser 40mj used with the phosphoric acid (46.99 MPa) in compare with aluminum oxide without phosphoric acid (12.24 MPa) Table (4).

DISCUSSION

Due to fact that an in vivo investigations and published reports about the re-

pair strength required for a satisfactory composite repair are few available. In contrast, the bond strength of composite to etched enamel has been extensively investigated and is reported to be about 15-30 MPa^(19, 20). And it is well known that composites seldom fail mechanically at the junction with etched enamel and it can therefore be surmised that a repair bond strength similar to that of composite to

etched enamel would be clinically adequate⁽²¹⁾. On the basis of this fact the results of our study would suggest that any of the surface treatment methods that produce adequate repair bond strength similar to that of composite to etched enamel.

Analysis with one-way ANOVA indicates significant differences between groups.

The sandblasting with a(50µm) particles Aluminum oxide showing a least shear value (12.24 MPa) in compare to other groups. Air abrasion removes some resin matrix and exposes the surface filler and results in surface roughness of composite resin⁽²²⁾. Some authors concluded that the sandblasting with aluminum oxide promoted the best bond resistance into the repair interface^(17, 23, 24). Other investigators noted a reduction in repair strength after surface abrasion^(25, 26), they have generally attributed this reduction in strength to the exposure of filler particles following abrasion, and hence reduced availability for primary bonding to the resin. Other possibilities are that surface debris interfered with the repair or that inclusion of air at the interface reduced the surface area available for bonding.

and this may have differentially exposed more filler particles than air abrasion methods. The smear layer created by a rotary instrument may also be more effectively penetrated or wetted if saline is applied⁽²⁷⁾.

increased⁽²⁸⁾, our results showed a significant difference from 40 to 80 mJ. They have been statistically expressive, with group 3(60 mJ laser), and 2(40 mJ

laser) showed the superior values of bond strength in repair interface but this result was disagree with Rossato et al⁽²⁹⁾ who found that no significant difference in shear value of repaired composite when composite surface treated with Er: YAG laser with a energy between 200 to 400 mJ because when energy exceeding 100 mJ destroys the composite resin restoration,^(30, 31) The acid conditioning as unique superficial treatment or combined with irradiation of Er: YAG at 60 or 100 mJ offered the best bond strength results⁽³²⁾. And as the enamel ablation is slower than ablation of composites, certain selectivity for con-

ditioning the composite with Er: YAG laser was shown⁽¹⁵⁾. Other study summarizes the results of the interaction of Er: YAG laser radiation with the hard dental tissues. It has been demonstrated that the higher energy (more than 200 mJ) of Er: YAG laser radiation might drill very well defined holes into the enamel and dentine. The energy below 200 mJ is sufficient for the tooth tissue conditioning⁽³³⁾.

For the acid etching, using of a phosphoric acid as a conditioning after treating the surface with aluminum oxide, bur, or Er: YAG laser radiation observed higher adhesion between the aged and repaired composite restoration, and agree with Groth⁽³⁴⁾ who noticed that irradiation with laser Er: YAG, previous to acid conditioning provide an increase in porosity, permitting higher acid penetration as well increase in the conditioning depth. This can explain the good results obtained with laser/acid association in our work. The more effective methods for removal of the debris may also be factors of contribution to these results, as showed by Armengol et al.⁽³⁵⁾ and Trajtenberg et al.⁽³⁶⁾, who, respectively, compared surfaces treated with laser + acid and only acid or laser.

CONCLUSION

With the limits of this in vitro study, superior shear value obtained with the Er: YAG laser when used for treatment the surface of old composite before it is repair in comperin with a diamond bur and aluminum oxide as while conditioning the aged composite surface with a phosphoric acid enhancing its adhesive result.

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