

Evaluation of Shear Bond Strength of Composite Resin to Dentin after Etching with Er,Cr:YSGG Laser And Conventional Acid Etch (An In Vitro Study

Assistant Lecturer Saif Nadhim Hassoon BDS, MSc..⁽¹⁾

Key words

Acid etching,
laser etching,
,shear bond
strength,
Er,Cr:YSGG
laser

Abstract

The aim of this study was to evaluate shear bond strength of composite to dentin after etching with conventional acid, Er,Cr:YSGG laser and Er,Cr:YSGG laser in conjunction with acid. Thirty recently extracted lower third molars were collected. Scaling and polishing of teeth were done. Roots of teeth were embedded inside self cured acrylic resin blocks to form acrylic base with occlusal surfaces parallel to base of blocks. Crowns of teeth were sectioned at one third of the crowns to obtain a flat dentin surfaces. Total number of samples were divided into 3 groups each of one contained (10) samples as following : Group 1- dentin surfaces were treated with 35% phosphoric acid only. Group 2- dentin surfaces were treated with Er,Cr:YSGG laser only. Group 3- dentin surfaces were initially treated with Er,Cr:YSGG laser, then with 35% phosphoric acid. Bonding agent was applied to dentin surfaces and composite was applied by using rubber mold then light cured. Composite posts were released from molds then shear bond strength was measured. Statistical analysis showed that there was significant difference among all groups and acid etching group showed significant highest Shear bond strength followed by group of laser & acid etching then group of laser etching showed the significant least shear bond strength. From this study it can be concluded that etching of dentin with Er,Cr:YSGG laser can produce shear bond strength weaker than that of conventional acid etching.

Introduction

The treatment of dental tissues prior to adhesive restorative procedures is an extremely important step in the bonding protocol and determines the clinical success of restorations. Dentin substrate is a complex structure which can influence the bonding of restorative systems; therefore, bonding to dentin surface is a greater challenge than to enamel surface(1). The bond between dentin and composite is more micromechanical than chemical (2). Preparation with rotating instruments produces a smear layer which contains hard particles, blood, bacteria and saliva (3). Acid etching dissolves the smear layer, demineralize the peritubular

and intertubular dentin and exposes the collagen matrix (2).

The demineralized dentin is infiltrated by resin monomers which create a hybrid layer after their polymerization (4). To create the hybrid layer, it is necessary to remove the smear layer and demineralize the superficial dentin layer. Etching exposes the collagen fiber network of the dentin matrix, thereby permitting infiltration of bonding agents into the spaces between the fibers (2). The fibers are engulfed and the complex fiber-resin is polymerized providing improved micromechanical retention of resin polymers (5).

In the 1990s Erbium lasers were introduced for the preparation of hard tissue. The Er,Cr:YSGG (Erbium, Chromium: Yttrium Scandium-Gallium-Garnet) laser and the Er:YAG (Erbium Yttrium Aluminum Garnet) laser are effective tools for the removal of dental hard tissues (6,7). The use of low energy lasers has increased for pretreatment of enamel and dentin in an attempt to optimize dental hard tissue conditioning in place of conventional acid etching for adhesive procedures (8, 9).

Laser irradiation on dental hard tissues is a process of continuous vaporization and micro-explosions resulting from vaporization of water trapped in the hydroxyapatite matrix (10).

Dentin irradiated with the Er,Cr:YSGG laser shows a microscopically rough surface (11) without demineralization, open dentinal tubules (12), no smear layer and satisfactory sterilization of the cavity (13). These characteristics are considered an advantage of laser use if composite resins are to be applied as filling materials (14).

The aim of this study was to evaluate shear bond strength of composite to dentin after etching with conventional acid, Er,Cr:YSGG laser and Er,Cr:YSGG laser in conjunction with acid.

Material and Methods

Thirty caries free recently extracted lower third molars were collected and stored in distilled water. Before the experiment, scaling of the teeth was achieved by using scaler (piezon Master 400 , EMS , Swiss) and Soft periodontal tissue was removed with hand curette (Lascod , Italy). After that teeth were polished with pumice by using rubber cup (DiaDent® , Korea) that was mounted to the slow speed contra angle hand-piece (Being Foshan medical Co. Ltd , China).

After that blocks of self cured acrylic resin (ProBase, Ivoclar, Vivadent, Liechtenstein) were made by using plastic tubes. These tubes had dimension of 2 cm in diameter and 2.5 cm in height. Before setting of self cured acrylic resin roots of teeth were embedded inside the blocks to

form uniform self cured acrylic resin base with the exposed crowns of teeth and occlusal surface of the crowns were parallel to the base of the acrylic resin blocks, after setting of self cured acrylic resin samples were ready. This provided more control and standardization during work.

The crowns of teeth were sectioned horizontally in the bucco-lingual direction at the level of one third of the crowns by using a diamond sectioning disk (GEBR.BRASSELER GmbH & Co. KG , Germany) that was mounted to the straight hand-piece (W&H , Austria) to expose the dentin and obtain a flat dentin surfaces (Fig.1). This cutting process was done with copious irrigation of distilled water to provide cooling and remove the debris that were produced during cutting.

A circular area of 4 mm in diameter was demarcated at the center of the exposed dentin surface of each sample by the application of an adhesive tape with a circular hole 4 mm in diameter on the exposed dentin surfaces, the margins of the tape were burnished to ensure complete adaptation of the tape to the exposed dentin surfaces thus standardized area was be exposed to the etching acid and /or laser also standardized area was be treated with bonding agent.

The total number of samples were divided randomly into three experimental groups each of one contained (10) samples as following :

Group 1 (Acid etching group): In this group demarcated area of the exposed dentin surface of each sample was treated with Cica etching gel (35% phosphoric acid)(Promedica dental material GmbH, Germany) (Fig. 2) only for 15 sec then etching gel was removed by rinsing for 20sec after that excess moisture was removed with an air blower during this dentin surface should not be completely dry, dentin surface should remain slightly moist where air-drying causes a dramatic collapse of the collagen network(15).

Group 2 (Laser etching group): In this group demarcated area of the exposed dentin surface of each sample was treated with Er,Cr:YSGG laser (Waterlase I plus , BioLase Technology, USA) (Fig. 3) only. Where laser beam was delivered through

laser tip mz6 (BioLase Technology, USA) with power settings of 2.5 W and 50 Hz under air/water spray. The dentin surface was lased in a circular pattern, for one min, in the non-contact mode perpendicular to the flat dentin surface with a 2-mm fixed distance between the laser tip and exposed dentin surface. To ensure consistent power density, spot size, distance, and hand piece angle, the laser hand piece was attached to a modified surveyor (Quayle Dental MFG Co., England) with acrylic holder that hung the laser hand piece (Fig. 4). subsequently excess moisture was removed with an air blower during this dentin surface should not completely dry but should remain slightly moist.

Group 3(Laser and acid etching group): In this group demarcated area of the exposed dentin surface of each sample was initially treated by Er,Cr:YSGG laser with the same manner of the group 2 (Laser etching group) , and then acid-etched by 35% phosphoric acid as mentioned with group 1 (Acid etching group) .

After the removing of the excess moisture light curing compobund1 bonding agent (Promedica dental material GmbH, Germany) (Fig. 5) was applied to the demarcated area of the exposed dentin surface of each sample with a disposable brush and let act for 30 sec. then compobund1 bonding agent was dispersed with a faint air jet and polymerized with led halogen light curing unit (LEDition Light curing unit , Ivoclar Vivadent , Austria) for 20 sec.

After that rubber mold that had central hole with dimension of 4 mm in diameter and 4 mm in depth was applied over the adhesive tape that was placed over the exposed dentin surface of each sample so that the hole in the rubber mold was positioned over the hole in the adhesive tape. Then rubber mold was fixed in its position by two points of wax (Dentaurum, Germany) to the acrylic block(Fig. 6).

Before the rubber mold fixation the mold was split vertically in one place through its entire thickness by using a surgical blade no.23 this facilitated the removal of the rubber mold from around the composite without putting excessive stress on the

composite sample. Subsequently composite(A2 composan ceram, Promedica dental material GmbH, Germany) (Fig. 7) was packed directly against the demarcated area of the exposed dentin surface through the rubber hole with ash plastic instrument (MEDESY , Italy), the composite was adapted into two increment of 2mm thickness of each increment to prevent air entrapment , after the application of the first increment the thickness of this increment was checked by using graduated periodontal probe (MEDESY , Italy) then light curing for this increment for 40 sec by using led halogen light. then the second increment was applied, covered with celluloid strip (PD, Switzerland) and also light cured for 40 sec. For standardizing the curing distance the tip of light curing unite was applied in contact with the surface of the rubber mold. After that wax points were removed and the composite posts were released from the rubber molds and the adhesive tape, then each composite post light cured for 40 sec at four point all around the composite post to ensure complete polymerization of composite.

The shear bond test was performed using digital force gauge (IMADA CO., LTD, Japan)(Fig. 8) through a blunt knife-edged apparatus that was applied to the interface between the composite and dentin at a crosshead speed of 1 mm/min. The maximum load to failure was recorded for each sample in Newton and the shear bond strength was calculated in (MPa) as a result of dividing the force applied (maximum load to failure) (in Newton) at the time of fracture by the bonded area of the exposed dentin.

Data was statistically analyzed using descriptive statistics, (Which include, mean, standard deviation, minimum and maximum values) parametric one-way ANOVA and post hoc Duncan's multiple rang test at a significance level of 5% . Differences were considered significant when $P < 0.05$.

Results

Number of samples, mean, standard deviation, minimum and maximum values

of Shear bond strength for experimental groups are shown in the table (1). These results indicate that acid etching group showed highest mean Shear bond strength followed by group of laser & acid etching then group of laser etching showed the least mean shear bond strength among all the experimental groups. The one-way analysis of variance (ANOVA) was used to compare among experimental groups. The one-way ANOVA showed a P-value of (0.000) so there was significant difference among experimental groups because $p\text{-value} < 0.05$ (Table 2). Duncan's multiple rang test revealed that there were significant differences between each group with the other experimental groups where group of laser etching showed significant least mean shear bond strength as compared with the other experimental groups followed by group of laser and acid etching and finally group of acid etching showed significant highest mean shear bond strength (Table 3) (Fig. 9).

Discussion

The bond strength of adhesive systems is one of the major factors to be considered in the placement of composite resins(16). Adhesion of restorative materials to dental substrates is a desirable property because it is closely related to the prevention of material dislodgement and marginal leakage(17). An effective adhesion to tooth structure is important to withstand the stresses resulting from polymerization shrinkage, thus retention and marginal integrity of restorations are preserved(16).

The results of the current study showed that significant highest mean shear bond strength was observed for acid etching group followed by laser and acid etching group then laser etching group showed significant least mean shear bond strength among all the experimental groups.

The bonding mechanism of composite resin to acid-etched dentin is well known and understood to be micromechanical (18,19). The formation of a hybrid layer and resin tags is essential to the establishment of a strong bond at the

dentin level(20) and may be achieved by complete dissolution of the smear layer and demineralization of intertubular and peritubular dentin by means of acid etching, resulting in an exposed collagen matrix which is infiltrated by resin that polymerizes in situ(19,21).

Previous reports claimed that there are certain advantages in bonding to lased dentin. The adhesive area is enlarged due to the typical scaly and flaky structure that dentin exhibits after laser irradiation (7,11,22,23). This is caused by the micro explosions that occur by the laser due to its thermo-mechanical ablation. The laser initially vaporizes water and other hydrated organic components of the tissue. On vaporization, internal pressure increases in the tissue until the explosive destruction of inorganic substance occurs(24). Since intertubular dentin contains more water and has a lower mineral content than peritubular dentin, it is selectively ablated more than the peritubular dentin, leaving protruding dentinal tubules with a cuff-like appearance(22). This may also contribute to an increase in the adhesive area. Patent tubules and the absence of a smear layer are additional factors that may enhance bonding to laser-treated dentin(11, 22, 23). Ceballos et al.,(25) results showed that the superficial part of the laser-modified layer was composed of a scaly surface layer in which collagen fibrils were completely melted and vaporized. It is possible that these parallel plates of flaky materials represented porous layers of melted minerals formed by micro-explosion, forming micro fissures that were partially infiltrated by the adhesive. Along the basal part of the laser-modified layer, remnant denatured collagen fibrils were fused and poorly attached to the underlying dentin substrate. The presence of this fused layer in which inter fibrillar spaces were lacking probably restricted resin diffusion into the subsurface intertubular dentin, resulting in lower shear bond strength(25). In addition to that laser irradiation produces no demineralization of peritubular dentin, so no hybridization of the lateral walls of dentinal tubules is occurred thus lower shear bond strength is expected (26). Martínez-Insua et al., (27) confirmed that

enamel and dentin surfaces conditioned by Er:YAG laser show extensive subsurface fissuring which is unfavorable to adhesion. Accordingly the significant lowest mean shear bond strength of laser etching group among all the experimental groups in the current study can be explained.

When acid-etching was used after laser irradiation, a substantial increase in shear bond strength was observed when compared with laser etching group, although it did not reach the shear bond strength values of acid etching group. The adjunctive use of phosphoric acid following by water-rinsing appeared to have eliminated the surface laser modified layer. However, the thermo-mechanical effects produced by laser irradiation probably extend into the subsurface dentin and undermine the integrity of the resin-dentin interface (23). Also acid resistance of the teeth increased after laser treatment;(28,29, 30) consequently, acid-etching might not totally expose the collagen matrix, especially in the peritubular region,(31) and the adhesion to composite resin can be reduced by the lack of resin infiltration into the demineralized dentin(4). all these reasons may explain lower shear bond strength of laser and acid etching group when compared with acid etching group without laser treatment.

Consistent with results of the present study Dunn et al.,(29) reported that only the acid-etched specimens had significantly higher shear bond strengths and acid-

etching was better than laser-etching. In addition, Torres et al.,(32) concluded that irradiation of primary dentin with the Er:YAG laser decreased the shear bond strength of total-etch and self-etching adhesive systems. Ceballos et al.,(25) showed that acid-etching alone yields shear bond strength values that are significantly higher than those achieved with laser ablation alone, or in combination with acid-etching. Comparable results to the results of the current study were reported by davari et al.,(1) who found that Mean shear bond strength for acid etching group were significantly higher than those for laser& acid etching group and laser etching group. Shahabia and Kharazifarb(33) found that shear bond strength in the laser group was significantly lower than that in the acid group and these results resemble the results of the present study.

Discussion

Under the conditions of this study, it can be concluded that etching by phosphoric acid is an effective technique of dentin etching for composite resin restorations and showed highest shear bond strength as compared with the other etching techniques followed by laser & acid etching and finally etching with laser alone showed least shear bond strength.

Table (1) Descriptive statistics for experimental groups.

<i>Groups</i>	<i>Etching</i>	<i>N</i>	<i>Mean</i>	<i>+ SD</i>	<i>Min.</i>	<i>Max.</i>
<i>1</i>	<i>Acid etching</i>	10	16.0503	1.08335	14.251	17.515
<i>2</i>	<i>Laser etching</i>	10	7.3243	0.55527	6.449	8.200
<i>3</i>	<i>Laser & acid etching</i>	10	8.2798	1.18083	6.687	10.668

Table (2): One-way analysis of variance.

ANOVA

<i>DATA</i>	Sum of square	df	Mean Square	F	p
<i>Between Groups</i>	458.122	2	229.061	238.909	0.000*
<i>Within Groups</i>	25.887	27	.959		
<i>Total</i>	484.009	29			

* : Significant difference among experimental groups at $p < 0.05$

df : Degree of freedom.

F : Scheduled value.

Table (3) Duncan's multiple rang test.

<i>Etching</i>	Mean	Duncan's group
<i>Laser etching</i>	7.3243	A
<i>Laser & acid etching</i>	8.2798	B
<i>Acid etching</i>	16.0503	C

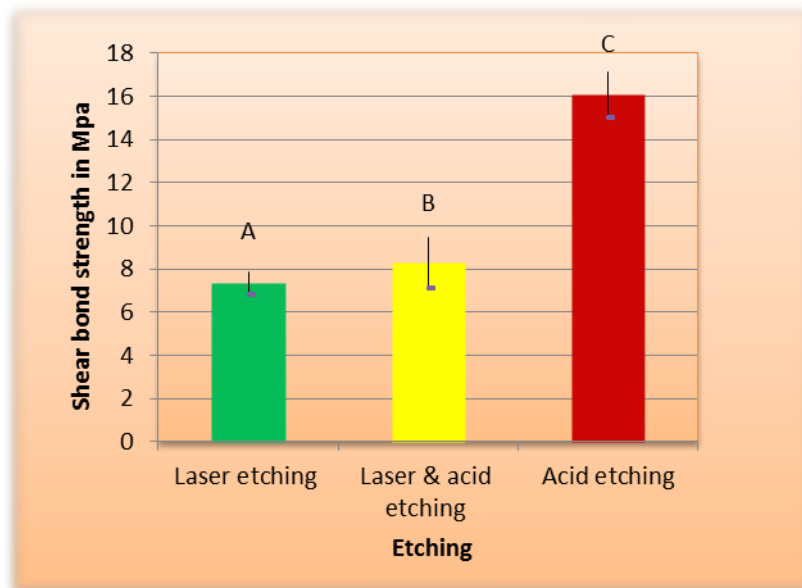


Fig. (9) Histogram shows there were significant differences between all the experimental groups.

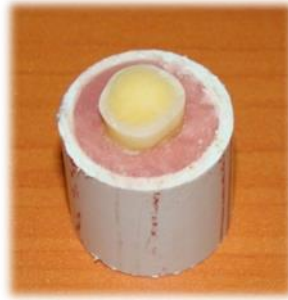


Fig. (1): Block of self cured acrylic resin in which roots of tooth were embedded and crown of tooth was sectioned horizontally.



Fig. (2): Cica etching gel.



Fig. (3): Er,Cr:YSGG laser



Fig. (4): Modified surveyor with acrylic holder that hung the laser hand piece



Fig. (5): Light curing compobund1 bonding agent.



Fig. (6): Rubber mold was fixed over the sample



Fig. (7) A2 composan ceram.



Fig. (8) Digital force gauge.

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