Comparison of shear bond strength of reattached incisor fragment using Er,Cr:YSGG laser etching and conventional acid etching: An in vitro study

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Aim: The aim of this in vitro study is to evaluate the shear bond strength of reattached fractured incisor fragments using Er,Cr:YSGG laser and conventional acid etching without additional tooth preparation.

Materials and methods: Forty extracted human teeth were divided in two groups of 20 each (Groups A and B). In Group A, fractured surface was treated by an Er, Cr: YSGG laser system (Waterlase MD, Biolase Technology Inc., San Clemente, CA, USA) operating at a wavelength of 2,780 nm and frequency of 20 Hz. In Group B, fractured surface was etched using 37% phosphoric acid (Scotchbond, 3M). In both the groups, further subdivision with 10 sample each was made based on horizontal and oblique fracture. After laser or acid etching, all the samples were reattached using flowable composite resin and light cured. The samples were tested for shear bond strength.

Results: Mean shear bond strength for Group A (94.70±39.158) was lower as compared to Group B (121.25±49.937), although the difference was not statistically significant (p value=0.121). Similarly no statistical significant difference was observed amongst the subgroups. (p>0.05)

Conclusion: Er,Cr:YSGG laser etching in reattachment of fractured incisor fragment is a good alternative to conventional acid etching. Er,Cr:YSGG showed comparable efficiency in rebonding of fractured teeth fragment as acid etching.

Introduction

The majority of dental injuries involve the anterior teeth, especially the maxillary central incisors, because of its position in the arch. 1, 2) The fractured teeth are generally restored using composite resin or complex ceramic restorations. With advancements in acid etching and adhesive resins, the reattachment of tooth fragment has become a commonly used procedure for fractured teeth. This treatment may offer several advantages over conventional composite restoration such as improved esthetics as original shape, color, brightness and surface texture of enamel are maintained. In addition, the incisal edge will wear at a similar rate to adjacent teeth. 3) Furthermore, this technique can be less time consuming which reduces the cost of the treatment. Many techniques have been proposed for reattaching the fragment to the remaining tooth viz. using a circumferential bevel before reattaching, 5, 6) placing a chamfer at the fracture line after bonding, 7, 8) using a V-shaped enamel notch, 9) placing an internal groove or a superficial over contour over the fracture line. Some authors have also indicated bonding with no additional preparation, however still no consensus has been reached as to which method has an edge over the other method. 10, 11)

Development of laser technology has enabled its use in multiple dental procedures, such as soft tissue operations, composite restorations, tooth bleaching, caries removal, and tooth preparations with minimal pain and discomfort as it does not involve either vibration or heat of air rotor handpiece. 12) Laser etching has become an alternative to acid etching of enamel and composite.
dentin as it has been reported to yield an anfractuous surface and open dentin tubules, both suitable for adhesion. Er, Cr:YSGG laser of wavelength 2780 nm is effective in cutting the tissue and preparing the cavity. There is no or little (2°C) temperature rise in the dental pulp when the laser is used along with a water-air spray. Enamel preparation using the Er, Cr:YSGG laser produces chalky surface. Scanning electron microscope (SEM) evaluation shows that the laser irradiation produces the surface with high retention for restorative material, making it suitable for composite restoration. A study by C. Fornaini et al. (2012) analysed the effects of Er:YAG laser on enamel and dentin in case of reattachment of fractured fragment and concluded that Er:YAG alone or in combination with phosphoric acid gives better results than acid alone. Re-bonding of a broken tooth fragment, following trauma, with an Er,Cr:YSGG laser was found to be very successful, maintaining stability and vitality of the affected tooth. Various studies have been reported on the use of Er,Cr:YSGG laser in bonding of orthodontic brackets with success, however to the best of our knowledge no study has been reported on Er,Cr:YSGG laser assisted incisor fragment reattachment except one case report.

The purpose of this study is to compare the shear bond strength (SBS) of reattached incisor fragment using laser etching and conventional acid etching.

Materials and methods

The study sample comprised 40 intact human maxillary central incisor teeth freshly extracted for periodontal reasons. The teeth that were within 1 mm difference of their mesio-distal widths, with incisal edges intact, free from cracks, caries or any other kind of structural defect were included in the study.

The teeth were rinsed under tap water in order to remove blood and tissue debris and disinfected using 5% sodium hypochlorite for half an hour and then stored in 0.1% thymol at room temperature until use. All specimens were mounted in standardized self-cure acrylic resin mould. After mounting, the teeth were randomly divided into two groups by simple random technique of flipping a coin, Group A and Group B (Figure 1), each comprising 20 teeth. Each group was further subdivided into two subgroups viz. A1, A2 and B1, B2 depending upon the fracture line as shown in flowchart below. The incisal third was sectioned with a water-cooled low-speed diamond disc according to the subgroup allocated.

In Group A, laser etching was done with an Er, Cr:YSGG laser system (Waterlase MD, Biolase Technology Inc., San Clemente, CA, USA) operating at a wavelength of 2780 nm and frequency of 20 Hz. Laser energy was delivered through a fiberoptic system to a sapphire tip terminal that was 600 µm in diameter and 6 mm in length. The power output was set at 1.5 W for 10 s of exposure time. Air and water spray from the handpiece was adjusted to a level of 60% air and 40% water.

In Group B, samples were etched with a 37% phosphoric acid gel (3M Scotchbond etchant, 3M Dental Products, St. Paul, MN, USA) for 15 s followed by 15 s of washing with distilled water and air dried.
for 10 s. After laser or acid etching, the samples were dried with oil-free air for 20 s; the light-cured bonding resin (Scotchbond Multipurpose, 3M Dental Products, St. Paul, MN, USA) was then applied immediately with a brush, and cured as per manufacturer’s instructions. The fragments were then reattached using flowable resin composite (Tetric flow, Ivoclar Vivadent, Schaan, Liechtenstein) and polymerized. The reattached teeth were finished and polished using Sof-Lex polishing discs (3M ESPE).

All the specimens were transferred to the Instron universal machine individually and subjected to Shear Bond Strength (SBS) analysis at constant crosshead speed of 1.0 mm/min. Shear bond strength was recorded in Newtons.

Statistical analysis

For SBS analysis, data were expressed as means ± standard deviation. All data was processed by SPSS software version 19.0 (SPSS Inc., Chicago, IL, USA). To investigate whether SBS was significantly affected by treatment options, Mann Whitney U test was used for both inter-group and intra-group comparison. Differences were considered significant for a value of p< 0.01.

Results

Results were evaluated by a blinded evaluator not involved in the experiment. Mean shear bond strength (SBS) for Group B was higher as compared to Group A, however the difference was not statistically significant as revealed by Mann Whitney U test (p=0.121). The values are depicted in Table 1 and Figure 2. Mean shear bond strength (SBS) values in subgroups of A and B are shown in Table 2 and Figure 3. No statistically significant difference was observed between the subgroups.

Discussion

Maxillary central incisors were included for the present study as these are more frequently involved in traumat-
ic dental injuries.2) According to a recent survey, over-
all prevalence of traumatic dental injuries was found to
be 10.4%, and maxillary central incisors were the most
commonly affected teeth (85.2%). The results of this
survey also showed almost equal frequency of horizon-
tal and oblique dentinal fractures.19) The fractured
teeth are generally restored using composite resin or complex ceramic restorations. With
advancements in acid etching and adhesive resins, the
reattachment of tooth fragment became a commonly
used procedure for fractured teeth. During rebonding
of fractured segment, acid etching results in chemical
changes that can modify the organic matter and decal-
cify the organic component. As a result of this demi-
neralization, enamel becomes more susceptible to
caries attack and sensitivity.20) In order to avoid this
demineralization, the present study aimed at utilizing
laser for etching the fractured surfaces and the results
were comparable to acid etch in terms of resistance to
debond the fragments. Er; Cr:YSGG laser was utilized
in the present study as it is well-absorbed by water and
dental hard tissue. As water absorbs laser radiation bet-
ter than dental hard tissue, it reduces the increasing
temperature of the tissue during the preparation. In
addition it provide a smear-free surface, good adhe-
sion, lack of vibration and lack of need for local anal-
gesia in most cases.21) It had been reported that the
use of a bur preparation, with an insufficient cooling,
may lead to a temperature rise of over 15°C when the
critical temperature rise lies at about or above 5.5°C, at
which a high percentage of the pulp cells are killed.
But for Er; Cr:YSGG laser preparations, with the sug-
gested cooling settings, a decrease in the temperature
of the pulp has been recorded.21) Laser prepared
enamel has a chalk-like appearance that is similar to
the acid etched characteristic of enamel and enamel
rods.22) The parameters of laser used in the present
study are as per the literature findings for etching pro-
cedure.23, 24) The mean shear bond strength of bond-
ed brackets and enamel surface etching pattern
obtained with an Er,Cr:YSGG laser (operated at 1W or
2W for 15 seconds) is comparable to that obtained
with acid etching.25) Similarly, Berk (2008)24) observed by means of a SEM analysis that 1 W, 1.5 W,
and 2 W Er, Cr:YSGG laser irradiation produced etch-
ing patterns similar to those of acid etching. The etch-
ing effect of Er, Cr:YSGG laser has been studied for
various purposes in dentistry like pit and fissure
sealant application, orthodontic brackets placement
and others, however only a single case is reported for
its use in bonding an incisal fragment with success
over a period of four years follow up.18) Various stud-
ies have evaluated the effect of different materials and
type of tooth preparation on shear bond strength of
reattached tooth fragment.1, 6, 7) Although, in clinical practice we do come across both horizontal and
oblique teeth fracture with equal frequency but to the
best of our knowledge, no study reported regarding
the type of fracture and its effect on bond strength. So,
in the present study, the effect of type of fracture on
shear bond strength was also evaluated. Bond strength
values are gross assessing tools for evaluating the effi-
cacy of bonding restorative materials to dentin. Of the
various tests, the shear bond strength is less technique
sensitive to perform, highlighting the strength at the
bonded interface.25) The cross-head speed used to
fracture the specimens in this study was 1mm/min as
recommended by ISO standard (ISO/ TS 11405:2003-
Dental Materials-Testing of adhesion to tooth struc-
ture).

The results of the present study showed that the
shear bond strength of acid etched bonded surfaces
was more as compared to laser etched surfaces, how-
ever, the difference was not statistically significant.
(Table 1, Figure 2) The use of lasers for enamel etch-
ing shows contradictory reports. Some researchers
stated that laser irradiation was not capable of etching
enamel. Martinez-Insua (2000) found weaker adhesion
forces in an Er:YAG laser-etched enamel surface than
an acid etched enamel surface.20) This was related to
sub-surface cracks observed in (SEM) images. Tarcin et
al. (2009) found that the microtensile bond strength
was significantly lower in the acid-etched group than
the Er, Cr:YSGG and Nd:YAG laser-etched enamel
group for two types of bonding agents used.26)
In contrast, some studies reported that laser
applications give similar results to acid-etching tech-
niques. Basaran et al. (2007) compared the SBS of
brackets using an Er, Cr:YSGG laser in 0.5 W, 0.75 W,
1 W, 1.5 W, 1.75 W, and 2 W. They stated that 1.5 W,
1.75 W and 2 W etching yielded similar success rates
as 38% phosphoric acid etching.23) Ozber et al.(2008)
investigated the SBS of brackets that they applied on
enamel prepared with 0.75 W Er, Cr:YSGG, 1.5 W Er,
Cr:YSGG, 37% orthophosphoric acid or self-etching
primer. They found that the 0.75 W laser-applied
groups was significantly less in regard to SBS than the
Er, Cr:YSGG and Nd:YAG laser-etched enamel
group for two types of bonding agents used.26)

Acid etching typically produced a repeating sur-
face pattern, with cracks and fissures no deeper than
12 mm that are readily filled with resin.12) In contrast
to acid etch treatment, laser etching produced extensive surface fissuring and less regular and less homogeneous surface patterns arising from the union of different craters and microexplosion. Fissuring may be related to the orientation of enamel rods, because enamel is an anisotropic material. One of the potential disadvantages of enamel acid etching is that the acid causes demineralization of the most superficial layer. As a result, this surface becomes more susceptible to long-term acid attack and caries, especially when resin impregnation is defective because of air bubbles or saliva contamination. In view of potential advantages and similar bond strength, lasers can serve as an alternative to acid etching for bonding the fractured incisor fragments.

Our results showed no statistically significant difference between horizontal and oblique fracture as far as the technique of bonding is similar in both types. (Table 2, Figure 3) This can be explained by the improved adhesive systems and composite resins in the last decades. Andreasen et al. (1995) reported their results on reattachment after acid etching alone and after acid etching together with dentin bonding agent. The rate of survival of restored teeth that had been etched with acid only was 50% at 1 year, whereas that of teeth restored with acid etching and a dentin bonding agent was 50% at 3 years.

**Conclusion**

Within the limits of an in vitro study, the use of Er,Cr:YSGG laser in reattachment of fractured incisor fragment is acceptable. However, larger sample size and in vivo studies are required to further enhance this finding.

**References**

17. C. Fornaini, S. Petruzzezza, R. Podda, E. Mergo, S.