THE EFFECT OF ER:YAG LASER CAVITY PREPARATION ON THE BOND STRENGTH OF ETCH-AND-RINSE AND SELF-ETCH ADHESIVE SYSTEMS

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ABSTRACT

Background and Aim: The aim of this study was to investigate the effect of Er:YAG cavity preparation on the microtensile bond strength of a two-step etch-and-rinse and a one-step self-etch adhesive.

Materials and Methods: Standardized Class I cavities (4.0 X 3.0 mm, 3.0 mm deep) were prepared with a carbide bur or an Er:YAG laser on twenty extracted human molar teeth. The specimens in each group were further divided into two subgroups according to the adhesive systems: XP Bond (two-step etch-and-rinse) and Xeno III (one-step self-etch). After applying the adhesive systems, the cavities were restored with a hybrid composite resin, Z250, and light-cured. Specimens were stored in water for 24 hours, then sectioned vertically into 4 or 5 slabs and trimmed for the microtensile bond strength (μTBS) test. The μTBSs were measured with a universal testing machine at a crosshead speed of 1.0 mm/minute. The data were analyzed with Mann-Whitney U-test.

Results: Higher bond strength values were obtained in cavities prepared with the bur than in those prepared with the Er:YAG laser when an XP Bond was used (p<0.05). No difference was observed between bur and laser prepared cavities bonded with Xeno III (p>0.05). While there were significant differences between adhesives in bur-prepared cavities (p<0.05), no difference was found in laser-prepared cavities (p>0.05).

Conclusion: Although bond strength of etch-and-rinse adhesive to bur prepared cavities was higher than laser prepared cavities, both adhesive systems showed similar bond strength values to laser prepared cavities.

Key words: Adhesive Systems, Laser, Microtensile Bond Strength

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ER:YAG LAZER KAVİTE PREPARASYONUNUN ETCH-AND-RİNSE VE SELF-ETCH ADEZİV SİSTEMLERİNİN BAĞLANMA DAYANIKLIĞI ÜZERİNE ETKİSİ

ÖZET


Gereç ve Yöntem: Yirmi adet çekilmiş molar dişe, karbid frez veya Er:YAG lazer ile Standart Sınıf I kaviteler (4.0 X 3.0 mm, 3.0 mm derinliğinde) açılmıştır. Her gruptaki örnekler, daha sonra kullanılan adeziv sistem göre iki alt gruba ayrılmıştır: XP Bond (iki-aşamalı etch-and-rinse) ve Xeno III (tek-aşamalı self-etch). Adeziv sistem uygulanmasının ardından, kaviteler bir hibrit kompozit ile, Z25, restore edildi ve ışıkla polymerize edilmiştir. Örnekler, su içerisinde 24 saat bekletilmiş, ardından vertical olarak 4 veya 5 dilime ayrılmış ve mikrogerilim bağlanma dayanıklılığı (μGBD) testi için trimlenmiştir. μGBD, kafa hızı 1.0 mm/dakika olan universal bir test cihazında ölçülmüştür. Veriler, Mann-Whitney-U testi ile analiz edilmişdir.

Bulgular: XP bond kullanıldığında, frezle prepare edilen kaviteler bağılanma dayanıklığı, Er:YAG lazerle prepare edilenlerin kıyaslada daha yüksek bulunmuştur (p<0.05). Xeno III adeziv sisteminin kullanıldığı frez ve lazerle prepare edilen kavitelerde bir fark bulunmamıştır (p>0.05). Frezle prepare edilen kavitelerde adezivler arasında anlamlı fark bulunurken, lazerle prepare edilenler arasında bir fark gözeikenmemiştir (p>0.05).

Sonuç: Etch-and-rinse adezivin frezle prepare edilen kavitelere bağılanma dayanıklığı daha yüksekken; her iki adeziv de lazerle prepare edilen kavitelere benzer bağılanma dayanıklığı göstermiştir.
INTRODUCTION

In the past, most cavity preparations were precise procedures, usually resulting in uniform depths, particular wall forms, and specific marginal configurations. The degree of precision of cavity preparations to achieve good retention has decreased with the availability of adhesive restorative materials and dentin adhesive systems, and the development of minimally invasive preparation techniques such as air abrasion and laser. Although laser technology was introduced into the dental field by Maiman in 1960, today it has become more popular as a result of altered concepts about cavity preparations. It has many advantages related to its ease of use and patient comfort. The Erbium:Yttrium Aluminum Garnet (Er:YAG) laser is one of the commonly used lasers, and it received FDA approval in 1997. As it operates at a wavelength of 2.94 mm in a pulsed waveform that is well absorbed by hydroxyapatite, it has a variety of hard-tissue applications such as caries removal, cavity preparation, and root canal preparation. However, the literature indicates some uncertainty over the efficacy of laser as a means of preparing hard dental tissue for adhesive dentistry. While some studies have suggested that bond strengths to laser-treated surfaces were comparable to those to bur-prepared surfaces, other studies have shown that the use of laser did not improve the bond strength of composite resin to dentin. On the other hand, it has been reported that satisfactory bond strengths are only achieved with laser-treated surfaces when they are also acid-etched.

Different cavity preparation techniques might lead to differences in the quality of dentin after preparation. These differences might be clinically significant when considering the surface bonding ability with different adhesive systems. Newer self-etch systems combine the etchant, primer, and adhesive in one container. As no separate etching or rinsing is required in these systems, the risk of errors during application is lower. The simultaneous occurrence of demineralization and resin infiltration is another benefit of self-etch adhesive systems. However, their ability to appropriately etch the mineralized tooth structure, as well as their bonding to such substrates, has been questioned. Assessments of the bonding performance of adhesive systems have been generally conducted on flat tooth surfaces without maintaining the cavity configuration factor, whereas in clinical conditions complex cavity designs are prepared. Therefore, it might be more clinically relevant to measure bond strength to prepared cavities. Moreover, the bonding performance of current self-etch systems to cavities prepared with a laser has not been thoroughly researched.

The aim of this study was to evaluate the effect of Er:YAG cavity preparation on the microtensile bond strength of a two-step etch-and-rinse adhesive (XP Bond) and a one-step self-etch adhesive (Xeno III).

MATERIALS AND METHODS

Twenty extracted non-carious human mandibular third molars were used. The teeth were cleaned with air/water spray to remove any debris. They were stored in 0.5% chloramine solution at 4°C and used within one month of extraction.

The teeth were randomly assigned to two groups of ten teeth according to the cavity preparation technique. Group I: Standard Class I cavities (4.0 X 3.0 mm, 3.0 mm deep) were prepared at the occlusal crown center with the pulpal floor ending at the mid-coronal dentin, with a #56 carbide bur (SS White Burs, Inc., Lakewood, NJ, USA) in high-speed turbine hand-pieces under constant water cooling. Group II: The cavities were prepared with the same dimensions as in group I using an Er:YAG laser. The Er:YAG laser device used was a Fidelis Plus II (Fotona d.d., Ljubljana, Slovenia) emitting at 2.94 mm wavelength. The parameter settings used were 300 mJ of energy and 30 Hz of pulse repetition for enamel and 140 mJ of energy and 30 Hz of pulse repetition for dentin. The laser beam was delivered using a sapphire tip in contact mode. The time of irradiation was an average of 45 s.

After cavity preparations, the teeth in each group were subdivided into two additional groups of five teeth according to the adhesive systems: A) XP Bond, two-step etch-and-rinse (Dentsply, Konstanz, Germany) B) Xeno III, one-step self-etch (Dentsply). Both adhesive systems were applied in accordance with the manufacturers’ instructions (Table 1). All cavities were restored with a hybrid composite resin, Z250 (3M ESPE, St. Paul, MN, USA) in three 1.0 mm horizontal increments. Each increment was light-cured with a quartz tungsten halogen light (Hilux, Benlioglu Dental, Ankara, Turkey) for 40 s. The light intensity was measured with a radiometer (Demetron, Kerr, Danbury, CT, USA) and resulted in 400 mW/cm².

After storage in distilled water at 37°C for 24 hours, specimens were vertically sectioned into four or five 0.7-mm-thick slabs using a low-speed diamond saw.
Buehler Ltd, Lake Bluff, IL, USA) under water lubrication. A total of 19-22 slabs in each subgroup were trimmed into an hourglass shape with approximately 1-mm² cross-sectional areas using a fine diamond bur. The specimens were attached to a Bencor Multi-T apparatus (Danville, Engineering Co., Danville, CA, USA) with a cyanoacrylate adhesive and subjected to microtensile testing using a universal testing machine (Instron Corp., Canton, MA, USA) at a crosshead speed of 1 mm/min (Figure 1).

**Statistical Analysis**

Microtensile bond strength (μTBS) test data were evaluated using commercial software (SPSS, version 15.0 for Windows; SPSS, Chicago, IL, USA). Because the groups did not exhibit normal data distributions, a non-parametric test was used. Pairwise differences between group means were analyzed using the Mann-Whitney U-test (level of significance, p<0.05).

**RESULTS**

The mean μTBS in MPa and standard deviation are shown in Table 2. The mean bond strengths to bur-prepared cavities that used etch-and-rinse adhesive were higher than those used self-etch adhesive and laser-prepared cavities irrespective of the adhesive system (p<0.00). No difference was detected between bur and laser prepared cavities when self-etch adhesive was used (p=0.079). While self-etch adhesive Xeno III showed significantly lower mean bond strengths than did the two-step etch-and-rinse adhesive XP Bond in bur-prepared cavities (p=0.00), no significant differences were found between etch-and-rinse adhesive and self-etch adhesive in laser-prepared cavities (p=0.262). Both adhesive systems showed similar bond strength values in laser-prepared cavities.

**DISCUSSION**

The findings of the present study indicated that the use of an Er:YAG laser for cavity preparation might adversely affect the bond strength of etch-and-rinse adhesive...
system, as lased cavities showed lower bond strength values than bur-prepared cavities that used etch-and-rinse adhesive systems. However, self-etch and etch-and-rinse adhesives showed similar bond strength values to laser prepared cavities. A possible explanation for the higher bond strength of etch-and-rinse adhesives observed in the bur-prepared cavities might be that the more pronounced etching effect of etch-and-rinse adhesive systems. A thick smear layer generally occurs after bur preparation. The acidity of self-etch adhesive might not be high enough to dissolve this created smear layer that blocks the intra- and interprismatic spaces. Therefore, it does not allow resin interdiffusion into the prepared surfaces. On the other hand, in studies evaluating the morphological features of laser-irradiated dentin, irregular scaly surfaces with the absence of a smear layer and exposed dentin tubules are generally observed. Self-etch systems may have the advantage that etching and impregnation with adhesive monomers occur at the same time. This might be the reason why self-etch adhesive bond more effectively to laser prepared cavities than to bur prepared cavities. Delfino et al. evaluated the influence of Er:YAG irradiation on the microtensile bond strength of an etch-and-rinse and a self-etch adhesive to laser-irradiated and bur-cut enamel. They found that bond strength values obtained using the Er:YAG laser were significantly lower than those obtained with the carbide bur. No difference was observed between the etch-and-rinse and self-etch adhesive systems when the cavity preparation was performed with the Er:YAG laser. The best results were obtained with the etch-and-rinse adhesive to the enamel prepared with the carbide bur. These results are in line with the present study as no difference in bond strength values were observed between etch-and-rinse and self-etch adhesive systems in laser prepared cavities. Brulat et al. compared the shear bond strengths of composite resin bonded to Er:YAG laser or bur-prepared dentin surfaces using three self-etching adhesive systems. One of the adhesives that were used was the same adhesive in our study. In agreement with the results of current study, they found no difference between bur and Er:YAG laser prepared surfaces when the Xeno III was used. In another study, evaluating enamel and dentin bond strength to composite resin following high-speed rotary or Er:YAG laser preparation using a total etch adhesive system, adhesion to laser-ablated or laser-etched enamel and dentin was found to be inferior to that of conventional rotary preparation and acid etching. Oliveira et al. evaluated the bond strength of two adhesive systems (Single Bond and Clearfill SE Bond) to cavities prepared either with high-speed diamond bur or Er:YAG laser. For dentin prepared at high speed, the total etching adhesive system was more indicated, whereas Er:YAG laser-preparation dentin was not influenced by the adhesive system. De Munck et al. assessed whether tooth prepared either by laser or bur was equally receptive to adhesive procedures. They also reported an adverse influence of laser cavity preparation on adhesion when etch-and-rinse was used. While self-etch adhesive bonded equally well to lased and bur-cut enamel, it showed lower bond strength values to lased than bur-cut dentin. Kameyama et al. determined the bond strengths to Er:YAG laser-irradiated and non-irradiated bovine enamel of one- and two-step self-etch adhesives and no significant differences were found between laser-irradiated and non-irradiated enamel. Concur with our results, it was concluded that Er:YAG laser irradiation of enamel did not affect the tensile bond strength of self-etch adhesives. On the other hand, there are controversy results about the bonding performance of adhesive systems to lased dentin.

### Table 2. Mean microtensile bond strengths in MPa (SD) of adhesive systems to bur- and laser-prepared cavities

<table>
<thead>
<tr>
<th>Cavity preparation technique</th>
<th>Adhesive systems</th>
<th>XP Bond</th>
<th>Xeno III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bur</td>
<td></td>
<td>21.79 (7.01)aA (n= 22)</td>
<td>12.72 (6.21)bC (n= 21)</td>
</tr>
<tr>
<td>Laser</td>
<td></td>
<td>10.86 (4.87)cB (n= 19)</td>
<td>8.99 (3.71)cC (n= 21)</td>
</tr>
</tbody>
</table>

n = Number of the slabs tested

Differences in superscript capital letters indicate statistically significant differences within columns, and differences in superscript lower case letters indicate significant differences within rows (p < 0.05)
Laser effects on bond strength of adhesives

Amaral et al.,29 evaluated the influence of thermocycling and water storage on the microtensile bond strength of composite resin bonded to Er:YAG-irradiated and bur-prepared enamel. They concluded that adhesion of an etch-and-rinse adhesive to Er:YAG laser-irradiated enamel was similar to adhesion in the bur-prepared groups in all periods of water storage and thermocycling. Ergücü et al.,13 examined the effect of Er,Cr:YSGG laser irradiation on the bond strength of a three-step etch-and-rinse and a two-step self-etch adhesive to sound and caries-affected dentin. They found that Er,Cr:YSGG laser irradiation exhibited similar bond strength values compared to that of conventional bur treatment, regardless of the adhesive system and type of treated dentin. Flury et al.10 concluded that bond strength values did not differ between the cavities prepared by laser and those by air turbine. Gurgan et al.,30 assessed dentin bond strength to resin composite following high-speed rotary or Er,Cr:YSGG laser preparation using two different adhesive systems. The results suggest that dentin surfaces prepared with the Er,Cr:YSGG laser and etched with the laser may provide comparable or increased composite resin bond strengths, depending on the adhesive used. Cardoso et al.,31 determined whether enamel prepared either by Er,Cr:YSGG laser or conventional diamond bur is equally receptive to adhesive procedures. One etch-and-rinse (OptiBond FL) and three self-etch adhesives (Adper Prompt L-Pop, Clearfil SE Bond and Clearfil S3 Bond) were applied on laser-irradiated and bur-cut enamel. The microTBS to laser-irradiated enamel was significantly lower than to bur-cut enamel with the exception of Clearfil S3 Bond, which bonded equally effectively to both substrates. They concluded that the bonding effectiveness of adhesives to laser-irradiated enamel depends not only on the structural substrate alterations induced by the laser, but also on the characteristics of the adhesive employed. In another study evaluating the effect of a Er:YAG laser on the bond strength to dentin of two self-etch and two etch-and-rinse adhesives, the etch and rinse adhesives bonded less effectively with lased dentin than with carbide bur-cut dentin, while self-etch adhesives bonded equally well with lased and bur-cut superficial dentin.32 Another study reported that the pretreatment Nd:YAG laser did not impair the dentin bond strength of the self-etch adhesives.33 These controversies might ascribe to variations in irradiation parameter settings as well as to differences in laser types.

As most in vitro adhesive studies evaluate bond strengths to flat enamel or dentin, it is very difficult to compare our results with the previous studies. We tested bond strength values in a prepared Class I cavity that has the highest C-factor, which is the ratio of the surface area of resin bonded to a preparation wall to that is free and available to flow during polymerization. The cavity model used in this study represents a clinical ‘worst case scenario’ as cavity preparation with opposing walls might result in the generation of an interfacial strain during resin polymerization.24,32 It is known that laboratory studies conducted at a low C-factor tend to overestimate bonding performance compared with those using high C-factor cavities.36,37 Within the limits of this in vitro study, it was found that the bonding efficacy of self-etch adhesive system to laser-prepared cavities was similar compared with that of bur-prepared cavities. However, further clinical studies are required to evaluate the long-term effects of these preparation techniques on the bond strength of different adhesive systems.

**CONCLUSION**

In the present study, in the comparison of the bonding effectiveness of the two-step etch-and-rinse adhesive (XP Bond) to the one-step self-etch adhesive (Xeno III), the microtensile bond strength of XP Bond exceeded that of Xeno III in bur-prepared cavities. However in laser prepared cavities both adhesive systems showed similar results and no difference were observed between self-etch and etch-and-rinse adhesive system. Therefore it might be assumed that the bonding effectiveness of self-etch adhesives is not affected from laser cavity preparation.

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**DISCLOSURE STATEMENT**

No conflicting financial interests exist.

**REFERENCES**


CLINICAL DENTISTRY AND RESEARCH


