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Assessment of shear bond strength between composite resin and enamel surface after treating with acid etching and laser etching

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Abstract

Background: This study was conducted for the assessment of shear bond strength between composite resin and enamel surface after treating with acid etching and laser etching.

Material and methods: 50 newly extracted, non-carious, intact permanent human central incisors were gathered. Any signs of fissuring or cracking in the teeth had been ignored. To reduce bacterial growth, all teeth were kept at 4°C in a 5% formalin solution that had been buffered with phosphate. Teeth had been cleaned with a gauge piece as well as let to air dry before use. Prior to the studies, teeth were set into a resin block, exposing the coronal part of the tooth with the use of a 2 × 2 metal block. For the purpose of evaluating bonding to enamel following acid etching (Group A) as well as laser etching (Group B), 50 teeth were utilized. The teeth were randomly assigned to each of the two groups (n = 25 teeth per group). Statistical analysis was conducted using SPSS software.

Results: In this study, the mean shear bond strength for Group A was found to be 63.79 MPa, but Group B's average shear bond strength was just 32.14 MPa. The samples from the acid etching group showed a much higher mean shear bond strength than the samples from the laser etching group, according to statistical tests.

Conclusion: Composites bonded with acid etching showed a greater mean shear bond strength than those bonded with laser etching.

Keywords: shear bond strength, composite resin, enamel, etching, laser.

Introduction

Conventional cavity preparation and direct bonding is an acceptable clinical procedure in operative dentistry. To achieve effective adhesion between dental tissue and restorative materials, the smear layer which is formed during removal of dental caries must be either removed or modified. Traditionally, after cavity preparation by rotary instruments, the enamel and dentin are prepared for resin bonding through acid etching and application of bonding agent. Self-etching primers have been developed that include both acid etchant and priming agents into a single acidic primer for simplified and faster conditioning of enamel and dentin.[1]

Acid etching of the enamel appears to improve the retention by selectively eroding certain hydroxyapatite formations and facilitating the penetration with the development of resin tags of about 6-12 mm in length.[2] Various procedures for acid etching have been proposed, though the most widely used at present for enamel is 37% phosphoric acid for 15 seconds.[3]

Laser irradiation has been introduced as an alternative method for preparing dental hard tissues. The Er:YAG laser is well-known for its ability to remove dental hard tissues with minimal injury to the pulp and without causing severe thermal side-effects such as cracking, melting or charring of the remaining tooth structure and/or surrounding tissues. The accepted theory about the mechanism of the Er:YAG laser is that the emitted laser is predominantly absorbed by the water molecules on tooth hard tissues causing abrupt heating and evaporation of water.

The high vapor pressure causes a micro-explosion sequence, which shoots small tissue particles; this is called ablation. Er:YAG laser is used for conservative removal of dental caries and has disinfecting and anti-bacterial properties.[4,5]

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Material and methods

50 newly extracted, noncarious, intact permanent human central incisors were gathered. Any signs of fissuring or cracking in the teeth had been ignored. To reduce bacterial growth, all teeth were kept at 4°C in a 5% formalin solution that had been buffered with phosphate. Teeth had been cleaned with a gauge piece as well as let to air dry before use. Prior to the studies, teeth were set into a resin block, exposing the coronal part of the tooth with the use of a 2 × 2 metal block. For the purpose of evaluating bonding to enamel following acid etching (Group A) as well as laser etching (Group B), 50 teeth were utilized. The teeth were randomly assigned to each of the two groups (n = 25 teeth per group). Statistical analysis was conducted using SPSS software.

Results

Table 1: Mean shear bond strength among specimens of both the study groups

Group	**Mean shear bond strength (MPa)**	**p- value**
Group A	63.79	0.001(Significant)
Group B	32.14	

The mean shear bond strength for Group A was found to be 63.79 MPa, but Group B's average shear bond strength was just 32.14 MPa. The samples from the acid etching group showed a much higher mean shear bond strength than the samples from the laser etching group, according to statistical tests.

Discussion

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.[6] The use of lasers like high power diode laser and neodymium-doped yttrium aluminum garnet (Nd:YAG) in endodontics is an innovative approach for disinfection, providing access to formerly unreachable parts of the tubular network, due to their ability to penetrate dental tissues better than irrigant solutions.[7] Laser etching has become available as an alternative to acid etching of enamel and dentin. Laser etching is painless and do not involve either vibration or heat, making this treatment highly attractive for routine use. Furthermore, laser etching of enamel or dentin has been reported to yield an anfractuous surface and open dentin tubules, both apparently ideal for adhesion.[8]

The irradiation distance is an important parameter because it is directly related to the laser ablation ability, surface morphology and the consequent success of the bonding procedure.[9] Different manufacturers offer various hand pieces; none of these handpieces has direct contact with the tooth surface during cavity preparation, even in contact mode (at very low distance). Considering the possibility of changing laser irradiation distance during operation, per the manufacturer's instruction, the operator can change the mode of operation, such as a contact or non-contact mode and focused or defocused mode, which results in different morphologic features of the bonding area for adhesion.[10-13]

In 1955, Buonocore introduced acid etching that resulted in a very significant increase in adhesion on the tooth–restoration interface. Acid etching removes the smear layer generated by cavity preparation. This layer is characterized by a low surface energy that reduces the strength of the bond between biomaterials and enamel or dentin.[14] This bonding mechanism involves micromechanical interlocking of resin tags into the dentinal pores created by acid etching.[15]

Composite resin restorations are commonly used to restore dental structures, but they typically illustrate lower bond strength when used on dentin compared with enamel. Progressing to increase the strength of this bond, several adhesive systems have been introduced.[16] Per the technique used and also the mechanism of adhesion, adhesive systems are broadly categorized into two main categories: total-etch and self-etch adhesive systems.[17]

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Shirani F et al (2014)[18] investigated the effect of Er:YAG laser irradiation distance from enamel and dentin surfaces on the shear bond strength of composite with self-etch and etch and rinse bonding systems compared with conventional preparation method. Two hundred caries-free human third molars were randomly divided into twenty groups (n = 10). Ten groups were designated for enamel surface (E1-E10) and ten for dentin surface (D1-D10). Er: YAG laser (2940 nm) was used on the E1-E8 (240 mJ, 25 Hz) and D1-D8 (140 mJ, 30 Hz) groups at four different distances of 0.5 (standard), 2, 4 and 11 mm. Control groups (E9, E10, D9 and D10) were ground with medium grit diamond bur. The enamel and dentin specimens were divided into two subgroups that were bonded with either Single Bond or Clearfil SE Bond. Resin composite (Z100) was dispensed on prepared dentin and enamel. The shear bond strengths were tested using a universal testing machine. Data were analyzed by SPSS12 statistical software using three way analysis of variance, Tukey and independent t-test. $P < 0.05$ was considered as significant. There was a significant difference between enamel and dentin substrates ($P < 0.001$) and between lased and un-lased groups; the un-lased group had significantly higher bond strength ($P < 0.001$). Shear bond strength increased significantly with an increase in the laser irradiation distance ($P < 0.05$) on enamel surfaces (in both bonding agent subgroups) and on dentin surfaces (in the Single Bond subgroup). Laser irradiation decreases shear bond strength. Irradiation distance affects shear bond strength and increasing the distance would decrease the negative effects of laser irradiation.

Hoshing UA et al (2014)[19] carried out an evaluation of the shear bond strength of composite resin bonded to enamel which is pretreated using acid etchant and Er,Cr:Ysgg. 40 extracted human teeth were divided in two groups of 20 each (Groups A and B). In Group A, prepared surface of enamel was etched using 37% phosphoric acid (Scotchbond, 3M). In Group B, enamel was surface treated by a an Er, Cr: YSGG laser system (Waterlase MD, Biolase Technology Inc., San Clemente, CA, USA) operating at a wavelength of 2,780 nm and having a pulse duration of 140-200 microsecond with a repetition rate of 20 Hz and 40 Hz. Bonding agent ((Scotchbond Multipurpose, 3M) was applied over the test areas on 20 samples of Groups A and B each, and light cured. Composite resin (Ceram X duo Nanoceramic restorative, Densply) was applied onto the test areas as a 3 × 3 mm diameter bid, and light cured. The samples were tested for shear bond strength. Mean shear bond strength for acid-etched enamel (26.41 ± 0.66MPa, range 25.155 to 27.150 MPa) was significantly higher ($P < 0.01$) than for laser-etched enamel (16.23 ± 0.71MPa, range 15.233 to 17.334 MPa). For enamel surface, mean shear bond strength of bonded composite obtained after laser etching were significantly lower than those obtained after acid etching.

Conclusion

Composites bonded with acid etching showed a greater mean shear bond strength than those bonded with laser etching.

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