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

Dr Bushra Irum , Assistant Professor, Department of Dentistry, Restorative
College of Dentistry , Najran University, KSA

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Abstract

Background: This study had been carried out for the comparison the shear bond strength of composite resin to enamel surface with laser etching and acid etching.

Materials and methods: To carry out this study, a total of 100 maxillary canines that had been recently extracted were utilized. These specimens were primarily categorized into two distinct groups: Group 1 underwent acid etching followed by enamel bonding, while Group 2 was subjected to laser etching prior to enamel bonding. Composite bonding to the enamel surface was performed in accordance with the specific methodologies of each group.

Results: Group 1 exhibited a mean shear bond strength of 49.58 MPa, in contrast to Group 2, which demonstrated a mean shear bond strength of 31.63 MPa. Subsequent statistical analysis revealed that the samples subjected to acid etching displayed a significantly higher mean shear bond strength compared to those treated with laser etching.

Conclusion: The mean shear bond strength of composite was greater after acid etching as compared to composite bonded following laser etching.

Keywords: Composite resin, acid etching, laser etching

Introduction

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.¹ This bonding mechanism involves micromechanical interlocking of resin tags into the dentinal pores created by acid etching.²

Acid etching of enamel has been shown to enhance retention by selectively dissolving specific hydroxyapatite structures, thereby promoting the formation of resin tags measuring approximately 6-12 mm in length. Various acid etching techniques have been suggested, with 37% phosphoric acid applied for 15 seconds being the most prevalent method currently employed for enamel treatment. Composite resin restorations are frequently utilized to repair dental structures; however, they generally exhibit lower bond strength when applied to dentin in comparison to enamel. To improve the bond strength, a range of adhesive systems has been developed. These systems can be classified into two primary categories based on the technique employed and the adhesion mechanism: total-etch and self-etch adhesive systems.³⁻⁵

Numerous companies manufacture total-etch adhesive systems, which can be categorized into either a three-step system (comprising an acid etchant, a primer, and an adhesive) or a two-step system (featuring an acid etchant along with a primer-adhesive combination in a single container).

Self-etch adhesive systems consist of a self-etching primer and an adhesive resin, available in either two separate bottles (two-step system) or as a single bottle combination (one-step system). The three-step total-etch adhesives are widely regarded as the benchmark for enamel bonding, primarily due to the robust bond achieved through the application of a solvent-free, neutral pH, hydrophobic adhesive resin layer as an independent step.⁶

Hence; the present study was conducted for assessing and comparing the shear bond strength of composite resin to enamel surface with laser etching and acid etching.

Materials and methods

To carry out this study, a total of 100 recently extracted maxillary canines were utilized. These specimens were primarily categorized into two distinct groups: Group 1 underwent acid etching followed by enamel bonding, while Group 2 was subjected to laser etching before enamel bonding. Composite bonding to the enamel surface was performed in accordance with the specific procedures of each group. Following the etching process, the teeth were dried, and a light-cure bonding agent was subsequently applied. A universal force testing machine was employed to evaluate the shear bond strengths of all specimens. The results were documented in Microsoft Excel, and statistical analysis was conducted using SPSS software.

Results

Group 1 exhibited a mean shear bond strength of 49.58 MPa, in contrast to Group 2, which demonstrated a mean shear bond strength of 31.63 MPa. Subsequent statistical analysis

revealed that the samples subjected to acid etching displayed a significantly higher mean shear bond strength compared to those treated with laser etching.

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

Group	Mean shear bond strength (MPa)	p- value
Group 1	49.58	0.001 (Significant)
Group 2	31.63	

Discussion

The bond strength of resin composites to enamel and dentin treated with Er,Cr:YSGG lasers continues to be a topic of discussion. It is important to note that the laser parameters required for conditioning enamel and dentin differ from those employed in cavity preparation. In the present study, a specific laser type was used, adhering to the manufacturer's fixed parameters for conditioning, which were set at 4.5 W and 50 Hz. Numerous studies have explored various characteristics of Erbium lasers, seeking to optimize outcomes and enhance both bond strength and the integrity of the marginal seal.^{7,8}

Usumez and Aykent⁹ modified the laser wavelength and applied the Er,Cr:YSGG laser to the enamel surface at power settings of (2 W, 20 Hz, 100 mJ) or (1 W, 20 Hz, 50 mJ). A reduction in power to half resulted in a decrease in the bond strength of the irradiated surface, although the outcomes varied. In the present investigation, a power level of 4.50 W with an energy density of 90 mJ was employed to irradiate both enamel and dentin groups, resulting in a higher shear bond strength compared to that reported in earlier studies.

The current investigation aimed to evaluate and compare the shear bond strength of composite resin to enamel surfaces treated with laser etching and acid etching techniques.

In this study, Group 1 exhibited a mean shear bond strength of 49.58 MPa, in contrast to Group 2, which demonstrated a mean shear bond strength of 31.63 MPa. Subsequent statistical analysis revealed that the samples subjected to acid etching displayed a significantly higher mean shear bond strength compared to those treated with laser etching.

Bahrololoomi Z et al.¹⁰ conducted a study to assess the impact of tooth preparation methods—specifically using a bur and an Er:YAG laser—on the shear bond strength of composite materials to the enamel and dentin of primary teeth. A total of seventy-five primary molars were collected, resulting in 150 specimens through mesiodistal sectioning. The specimens were randomly divided into three subgroups within both the enamel and dentin categories, each subjected to one of the following preparation techniques: bur preparation followed by etching with 37% H₃PO₄, laser preparation with subsequent etching, and laser preparation without etching. All samples received the application of Single Bond adhesive and Z250 composite. The findings revealed that the bond strength of enamel specimens was significantly greater than that of dentin specimens, with the exception of the groups that underwent laser preparation without etching. Notably, there was no significant difference in bond strength between the enamel and dentin specimens in the laser-non-etched groups. Among the various preparation methods, bur preparation combined with etching produced the highest bond strength, followed by laser preparation with etching, while laser preparation without etching resulted in the lowest bond strength ($P < 0.001$). Overall, laser preparation was associated with reduced shear bond strength compared to bur preparation in both enamel and dentin groups.

Al Habdan AH et al.¹¹ compared the shear bond strength of enamel or dentin conditioned with either Er,Cr:YSGG (erbium, chromium: yttrium–scandium–gallium–garnet) laser or phosphoric acid to composite resin restoration. Forty posterior human extracted teeth were used. After mesiodistal sectioning of the teeth crowns, the samples were randomly divided into two groups—in the first group (E), bonding was performed on the enamel after roughening and in the second group (D), the enamel was removed and bonding was performed on the dentin. These groups were further randomly divided into two subgroups according to the type of etching ($n = 20$ each). In the acid-etched groups (EA and DA), the surfaces were etched with 37% phosphoric acid. In the laser-conditioned groups (EL and DL), the surfaces were conditioned with Er,Cr:YSGG laser. Total-etch adhesive system was used to bond all the 80 specimens resin composite. The composite was vertically light-cured, and the specimens were subjected to a shear bond strength test. Modes of bond failure were determined with a stereomicroscope. The highest shear bond strength was observed for the DA group (16.25 ± 1.10 MPa, $p < 0.0001$), whereas the lowest was observed for the DL group (8.56 ± 0.67 MPa). The adhesive failure mode was the most frequently observed in all groups. The shear bond strength of composite resin bonded to enamel and dentin etched with

phosphoric acid was higher than when conditioned with Er,Cr:YSGG laser. Thus, laser conditioning is not recommended.

Conclusion

The average shear bond strength of the composite was greater following acid etching in comparison to that of the composite bonded after laser etching.

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