# Comparison of Tensile Bond Strength of Composite to Dentin in Conventional or Laser-prepared Cavities (Er;Cr:YSGG)

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**Purpose:** The purpose of this study was to evaluate the effect of Er;Cr:YSGG laser on the tensile strength of composite resin to dentin in comparison with bur-cut cavities.

**Materials and Methods:** Twelve extracted caries-free human third molars were selected to prepare 24 samples (n = 24). The teeth were cut under the occlusal pit and fissure level and randomly divided into 2 groups. Six cavities were prepared with a diamond fissure bur No.1 and the other group with Er;Cr:YSGG laser with the pre-settings recommended by the manufacturer (power: 3.5 W, 65% water, 55% air). Then, all the cavities were restored using composite resin. The teeth were sectioned longitudally with an Isomet saw and the dumbbell-shaped specimens were prepared. The samples were attached to special jigs, and the tensile bond strength of the two groups was measured in a universal testing machine at a crosshead speed of 0.5 mm/min. The results were analyzed with the Kolmogorov-Smirnov test.

**Results:** The means and standard deviations of tensile bond strength of bur-cut and laser-ablated dentin were $5.04 \pm 0.93$ and $4.85 \pm 0.93$ MPa, resp. There was no significant difference between the tensile bond strength in lased and bur-cut cavities ($p = 0.5$).

**Conclusion:** There is little difference in the tensile bond strength of composite resin in laser-prepared vs bur-prepared cavities. According to the results, the Er;Cr:YSGG laser technique can be an alternative to the conventional methods for preparing cavities.

**Keywords:** Er;Cr:YSGG laser, resin composite, tensile strength.

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Proper preparation of the dentinal tissues before using adhesive systems is an important step in the bonding protocol in order to reduce microleakage and lead to the success of the restorations.[1]

Associated with recent developments in restorative dentistry and the introduction of the concept of minimally invasive dentistry, special attention has been focussed on using lasers for cavity preparation.[2] In recent years, different kinds of lasers have been used for preparing cavities. Nd:YAG laser is not an appropriate device for cavity preparation because it is not well absorbed by dental tissue. $CO_2$ laser has a very high absorption in hydroxyapatite, but it is not a suitable device because it can increase the temperature of dental pulp. Studies have shown that using $CO_2$ and Nd:YAG lasers in cavity preparation results in melting and recrystalization of tissue.[3,4] In order to avoid these drawbacks, the family of Erbium lasers with two different wavelengths was introduced. These laser wavelengths are absorbed by collagen, hydroxyapatite, and water, allowing the lasers to cut both soft and hard dental tissues.[5]

Like the Er:YAG laser, the Er;Cr:YSGG laser of 2780-nm wavelength is effective in cutting the tissue and preparing the cavity.[6] There is no or little (2°C) temperature rise in the dental pulp when the laser is used with water-air spray.[7] Rizoiu et al[8] evaluated the Er;Cr:YSGG and stated that this device has the ability to make a precise cut in dental hard tissue via the interaction of laser energy with water in tissue interface. Thus, the term "hydrokinetic system" was used for this device.[8,9] Enamel preparation using Er;Cr:YSGG laser produces a chalky surface. SEM images show that laser irradiation produces a surface with high retention for the restorative material, making it suitable for composite filling materials.[10] There are several studies about the effect of erbium laser irradiation on the bond strength, with controversial results. Amaral et al,[2] in assessing the bond durability in Er:YAG laser-irradiated preparations, used sectioned bovine incisors. Evaluation of the bond strength of the restored cavities prepared by Er:YAG showed results similar to those of bur-cut prepared cavities.[2] Ramos et al[11] evaluated the effect of Er:YAG laser on tensile bond strength and on dentin tissue through SEM and TEM, concluding that the use of Er:YAG laser for ablating human dentin did not alter the main adhesion parameters compared with those obtained by conventional methods. Tseng et al[12] performed a study about the effect of cavity preparation using Er;Cr:YSGG laser vs burs on the tensile bond strength of composite inlays to human dentin. They concluded that the tensile bond strength in dentin cavities prepared by Er;Cr:YSGG laser was lower than that prepared by burs.[12] Thus, the purpose of this study was to compare the tensile bond strength of composite resin to dentin in cavities prepared with Er;Cr:YSGG laser or conventional burs.

## MATERIALS AND METHODS

Twelve extracted impacted human third molars were used in this study. They were free of caries, restorations, and fractures. All teeth were stored in distilled water with 0.4% thymol for 1 month to eliminate bacteria. The storage solution was replaced every week.

First, all teeth were cut below the occlusal pit and fissure level by means of a high-speed turbine with a diamond fissure blade to expose the dentin. Then, the surface was mechanically polished using a carbon disk (Malekteb; Tehran, Iran).

The teeth were randomly divided into two groups – bur and laser – of 6 teeth each. In the bur group, occlusal cavities with the dimensions of 7 mm length x 6 mm width x 2 mm depth were prepared by fissure bur No. 1 accompanied by water and air spray. In the laser group, cavities of the same dimensions as in the bur group were prepared on exposed dentin surfaces using a Er;Cr:YSGG laser (Waterlase, Biolase; Irvine, CA, USA). The laser used in this study operates at a wavelength of 2780 nm and a pulse duration of 140 µs, with a repetition rate of 20 Hz. The manufacturer's pre-settings used for preparing the cavities were power: 3.5 W, 65% water, 55% air. The 6-mm-long G6 tip (diameter = 600 µm) was used at a distance of 1 to 2 mm above the surface for preparing the cavities. All procedures was performed by an expert operator.

The cavities were etched with phosphoric acid gel (Etch Royale, Pulpdent; Watertown, PA, USA) for 15 s and rinsed with air-water spray for 20 s. Then, the dental adhesive (Adper Single Bond, 3M ESPE; St Paul, MN, USA) was massaged into the cavity by means of a brush. The light curing unit (Coltolux; Cuyahoga Falls, OH, USA) was applied to cure the adhesive for 40 s. Subsequently, the composite resin (Filtek Supreme XT, 3M ESPE) was placed into the cavity incrementally. Each layer of composite resin was less than 2 mm thick and was cured for 40 s at distance of 2 mm above the surface. Next, a resin rod with dimensions of 7 mm x 6 mm x 7 mm was formed. Then, the composite resin restorations were polished. The teeth were stored in water 37°C for 24 h in an incubator in order to allow final adaptation of the material into the cavity.

The teeth were embedded in clear acrylic to prepare the 1.5-mm-thick slabs by using a high-speed diamond cylinder. In both lased and bur-cut cavities, 12 slabs were obtained. The slabs were trimmed to dumbbell-shaped specimens with dimensions of 4 x 2mm. The prepared specimens were attached to the special jigs using cyanoacrylate (Mitreapel, Beta Kimya San. Ve TIC; Iran). The tensile bond strength was measured with a universal testing machine (Zwick; Ulm, Germany) at a crosshead speed of 0.5 mm/min. The results of the two groups were analyzed with the Kolmogorov-Smirnov test.

## RESULTS

The means and standard deviations of tensile bond strength of bur-cut and laser-ablated dentin were 5.04 ± 0.93 and 4.85 ± 0.93 MPa, respectively. No statistically significant difference was found between bur-cut and laser-ablated groups.

## DISCUSSION

Various factors can influence the tensile bond strength of a restorative material to dentin, such as location of dentin, dentin tubular pattern, presence of smear layer, and pathophysiological changes such as erosion or abrasion.[13] To achieve optimal results in the bonding process, we should thoroughly understand all the properties of dentin prepared with different procedures.[5]

The purpose of this study was to compare the tensile bond strength of composite resin in cavities prepared by Er;Cr:YSGG laser and diamond burs.

Research has shown that, after using Er;Cr:YSGG laser irradiation, no demineralization of peritubular dentin can be seen and dentinal tubules remain open with no widening. It also produces no smear layer on the surface.[14] The Er;Cr:YSGG laser of 2780 nm wavelength has a high absorption in hydroxyapatite. This device has been shown to create precise hard tissue cuts by laser energy interaction with water at the tissue surface. The laser initially vaporizes water and other hydrated organic components of the tissue. During this process, the internal pressure increases in the tissue until the explosive destruction of inorganic substances occurs via hydrokinetic forces that can quickly ablate the dental hard tissues. The intertubular dentin contains a large amount of collagen matrix which is rich in water, making it suitable for absorption by laser energy. In contrast, the peritubular dentin lacks collagen but has a high mineral content. Therefore, the intertubular dentin is selectively more ablated than the peritubular dentin, leaving protruding dentinal tubules.[15-17]

Er;Cr:YSGG laser irradiation produces changes in the composition and conformation of the organic matrix on the dentin surface, resulting in partial collagen degradation. Since the remaining denatured collagen fibrils are fused together, adequate resin diffusion into the interfibrillar collagen spaces is prevented, compromising the bonding effectiveness.[1] However, if acid etching is performed following Er;Cr:YSGG laser irradiation, the mineral content of dentin is removed and dentinal tubule orifices are widened, which facilitates the deep infiltration of bonding agent.[19]

In comparison with conventional methods for cavity preparation, laser irradiation has the potential to reduce the postoperative sensitivity in vital teeth. Coagulation of proteins from the dentinal fluid after laser irradiation could decrease the permeability, leading to reduced dentin hypersensitivity. On the other hand, it has a great potential for microbial reduction, since its high absorption in water present in the bacteria results in cellular death.[20]

In this study, we used Er;Cr:YSGG laser with an output power of 3.5 W. According to Tseng et al,[12] no microcracks were seen with this laser power output under SEM examination. In addtion, using water spray during laser irradiation resulted in the least carbonated and charred dentin surfaces.[13] Besides the ability of water to decrease the temperature and avoid harmful effects to dental pulp, it can increase the cutting efficacy, since the ablation mechanism is water dependent.[21]

The findings of this study showed that the bond strength of composite resin to dentin in lased cavities was approximately the same as in bur-cut cavities. In agreement with the results of this study, Lee et al[13] demonstrated that acid etching following Er;Cr:YSGG laser irradiation increases the tensile bond strength to the level of that of bur-cut/acid-etched human dentin. In contrast, some other studies indicated that using laser could decrease the bond strength. Tonami et al,[22] in evaluating the effects of laser irradiation on tensile bond strength of bovine dentin, concluded that laser irradiation could possibly decrease dentin tensile strength. Also, Yousefi Jordehi et al[23] assessed the microtensile bond strength of glass-ionomer cements to dentin conditioned with Er;Cr:YSGG laser and found that laser irradiation did not only not improve the bond strength, it even reduced it. One reason for the lower bond strength on lasered dentin is that the hybrid layer is not formed after laser irradiation.[24] Another reason for decreasing the bond strength after laser irradiation is that the irregularities produced on dentinal surface result in a non-uniform thickness of the adhesive layer.[25]

To evaluate the failure mode of our samples, an optical microscope (Olympus SZX12; Tokyo, Japan) at 25X magnification was used. In the laser group, 10 samples failed adhesively at the interface of composite to tooth, and 2 samples failed adhesively at the interface of bonding and tooth. In the bur group, all the 12 samples showed adhesive failure at the interface of composite and tooth.

It is suggested that the different parameters of the erbium lasers can be used for cavity preparation to obtain positive effects on tensile bond strength.

## CONCLUSION

Cavities prepared with Er;Cr:YSGG laser irradiation yield the same bond strength of resin to dentin as does bur preparation. According to the results, the Er;Cr:YSGG laser technique can be an alternative to the conventional methods for preparing cavities. In addition, regarding the development of laser use in restorative dentistry, further studies should be conducted to improve bonding to surfaces prepared by laser.

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