Composite resin bond strength to primary dentin prepared with ER, CR:YSSG laser

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This in vitro *study evaluated the shear bond strength of a hybrid composite resin bonded to primary dentin prepared with an Er,Cr:YSGG hydrokinetic laser compared to conventional bur prepared primary dentin. The results suggest that primary dentin surfaces treated with the Er,Cr:YSGG laser, with or without etching, may provide comparable or increased composite resin bond strengths depending upon bonding agent used.*

J Clin Pediatr Dent 30(1): 45-50, 2005

INTRODUCTION

Composite resins and glass ionomers increasingly are becoming the materials of choice for restoring primary teeth.[1] Dentists continually strive for a means to efficiently and conservatively treat carious lesions in primary teeth, while managing the young child patient. Recently, hard tissue cutting lasers have been gaining favor for their increased efficiency, often without the use of local anesthesia.[2] Time, efficiency, and patient comfort are important factors in determining a successful pediatric dental visit for both the patient and pediatric dentist. Lasers seem to satisfy these requirements.

There are physiological and morphological differences between the primary and permanent dentitions. These differences in primary teeth include less enamel, pulpal anatomy that closely follows the dentin-enamel junction, and differences in tubular dentin.[3-5] Some investigations have shown no differences in shear bond strength of composite resin bonded to permanent tooth enamel and dentin surfaces that were treated with certain types of lasers compared to conventional methods alone.[6,7] Certain types of lasers may be used in conjunction with traditional tooth cutting methods to conservatively treat carious lesions in the pediatric dental population, while potentially decreasing patient discomfort and maintaining adequate shear bond strengths of composite resins to enamel and dentin.[2,8]

Laser interactions with biocalcified structures have been identified using different wavelengths. Studies have shown that CO_2 and Neodimium Doped Yttrium Aluminum Garnet (Nd:YAG) lasers may melt or crack enamel surfaces and induce adverse thermal effects on the pulp.[2,9-13] Recently, laser devices have been introduced becoming clinically practical and may safely cut hard tissues. The erbium:yttrium-aluminum-garnet (Er:YAG) lasers, emitting at a wavelength of 2.94 µm, have been shown to ablate (remove) enamel and dentin effectively.[2,14,15] Animal histological studies have demonstrated that this laser produces minimal thermal damage to pulp and surrounding tissues, especially when used with copious amounts of water.[16,17] Another device that emits at a wavelength of 2.78 µm is the erbium, chromium:yttrium-scandium-gallium-garnet (Er,Cr:YSGG) hydrophotonic pulsed laser system. This laser has been shown to cut tooth surfaces cleanly and efficiently without formation of a smear layer, and without detrimental effects to the pulp and biocalcified

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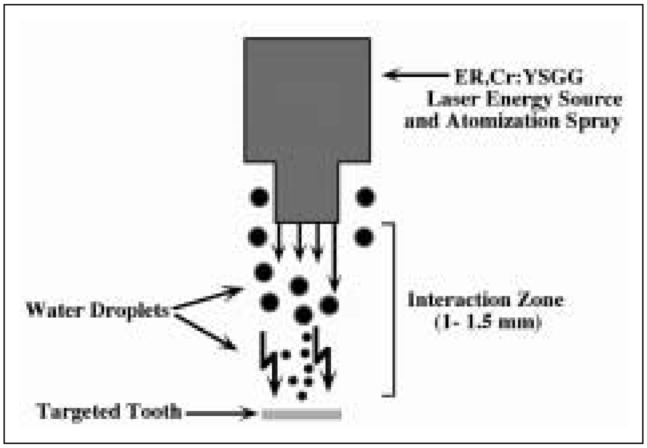

Figure 1. Mechanism of cutting action for Er,Cr:YSGG hydrokinetic pulsed laser system.

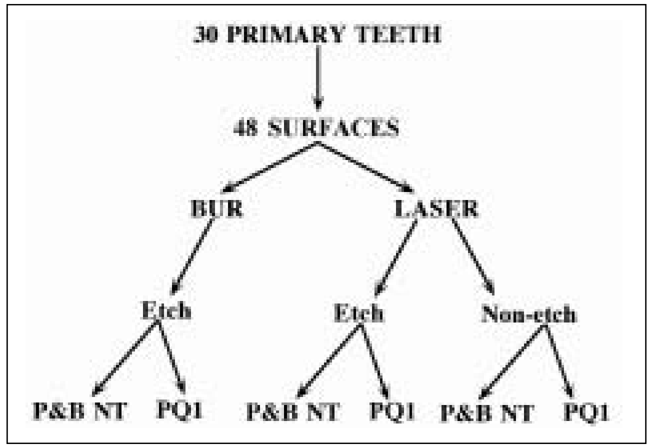

Table 1. Flow chart illustrating distribution of laser and bur cut primary dentin surfaces into different groups using two bonding agents Prime and Bond NT and PQ1.

structures.[2,18-22] This laser transfers energy to a sapphire tip using fiber optics and is used in conjunction with an air-water spray (Figure 1). The laser energy is absorbed by water microdroplets and extra-crystalline matrix fluid. This process, better described as molecular excitation and propulsion of water microdroplets, is hypothesized to produce micro-expansion that is responsible for the hard tissue cutting and removal of debris.[23, 24]

Bond strength of composite resins to lased tooth surfaces in conjunction with various bonding agents has been evaluated using both shear and tensile strength tests. These surfaces have been investigated using an etch or non-etch technique and have been compared to traditional acid etched bur cut surfaces.[7] Prior investigations also have compared shear bond strengths of composite resins to permanent enamel and dentin surfaces cut with an Er:Cr:YSGG laser as well as looking at topographical characteristics. One investigation showed no differences in shear bond strength of composite resin bonded to permanent tooth enamel and dentin surfaces that were treated with an Er:Cr:YSGG laser.[7] Some researchers have documented that lased tooth structure may show improved bond strengths to composites, increased surface enamel resistance to acid attack, decreased marginal microleakage, and possibly eliminate the need for etching prior to bonding.[20,21,25-27] However, little research has been done comparing dentin shear bond strengths of composite to primary tooth surfaces prepared with a laser.

The purpose of this investigation was to compare the shear bond strengths of composite to primary dentin when prepared with an Er,Cr:YSGG laser to that of surfaces cut with a bur using different bonding agents and etching protocols.

MATERIALS AND METHODS

Thirty primary teeth were stored in a 0.9% saline solution at 22°C immediately after extraction. The radicular portions of the teeth were mounted in acrylic and then were separated into two groups for subsequent laser and bur cutting (controls). These groups were further subdivided depending on type of bonding agent and surface treatment to be rendered (Table 1). The crowns of the teeth were cut to a depth exposing a 3 x 3 mm vertical area of dentin using a standard high speed dental handpiece (Midwest Dental Products, Corp, IL.) and a new No. 56 straight fissure carbide bur (Brasseler USA™ Savannah, GA). The handpiece mounted on a stationary jig with a sliding attachment for teeth that allowed vertical cuts to be standardized (Figure 2A). A total of forty-eight surfaces were prepared on non-carious surfaces of the teeth.

For all the laser groups, the surfaces were cut with an Er,Cr:YSGG laser HKS (Waterlase system, BioLase Technology, Inc, San Clemente, CA.). The tip of the laser was run across the dentin surface occlusogingivally for all primary dentin surfaces. The laser operated at a wavelength of 2.78 mm, at a pulse duration of 140 μs, with a repetition rate of 20 Hz. Laser energy was delivered through a fiberoptic system to a sapphire tip, which was 600 microns in diameter. The tip was bathed in an adjustable air-water spray delivered continuously during cutting. A power output of 0.75 W (53.1 J/cm^2) was used to ablate the primary dentin to a depth of approximately 0.25 mm . The same operator performed all laser treatments.

One-half of all lased surfaces and all bur cut surfaces were etched with a 37% phosphoric acid gel for 15 seconds and rinsed with water. The surfaces were air dried for one second. Two different dentin bonding agents were used for composite shear bond strength testing. Half of the bur and laser surfaces were prepared for composite bonding using PQ1 (Ultradent Products, Inc., South Jordan, UT). The other half of the bur and laser surfaces were prepared for composite bonding using Prime and Bond NT (Dentsply Caulk, Milford, DE). A uniform layer of adhesive was applied with a

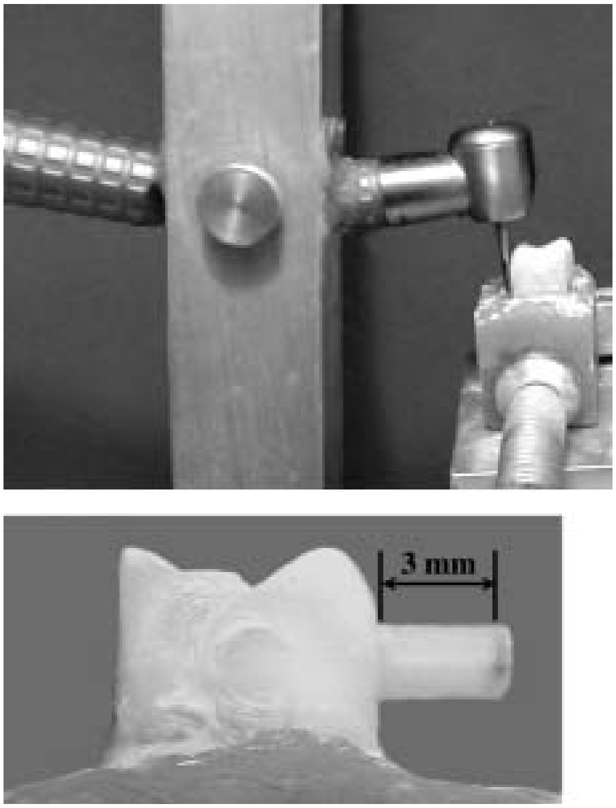

Figure 2. Preparation of shear bond strength specimens. **A)** Handpiece jig used to make reproducible vertical flat, bur cut primary dentin surfaces. **B)** Clear plastic tube containing 3 x 1.5 mm cylinder of composite resin bonded to the primary dentin surface.

brush to all surfaces for each of the bonding agents. All surfaces were light cured for 20 sec in accordance with the manufacturers directions with an Optilux 401 light curing unit (Demetron Research Corp, Danbury, CT).

A 3 mm transparent plastic tube of 1.5 mm inner diameter was filled with composite (Herculite XRV, Kerr Corporation, Orange, CA.) and placed on the treated surface (Figure 2B). Excess composite extruding from the cylinder-dentin interface was removed with an explorer prior to light curing. The composite cylinder was cured for 60 seconds, moving the light to assure curing from all sides. Each tooth received one to four cylinders of composite depending on available number of surfaces for shear bond strength testing. Teeth with bonded cylinders were carefully placed in sealable plastic bags humidified with 0.9% saline solution moistened paper towels. Teeth were stored for one day prior to shear bond strength testing.

Shear bond strength tests were performed on an Instron testing machine (Instron Corp, Canton, MA.) at a crosshead rate of 0.05 in/min using a knife shaped loading head until the cylinder was dislodged from the tooth (Figure 3). The teeth were oriented in a vise so that the loading head was perpendicular to the composite cylinder-tooth interface. The knife head was less than 0.25 mm from the cylinders.

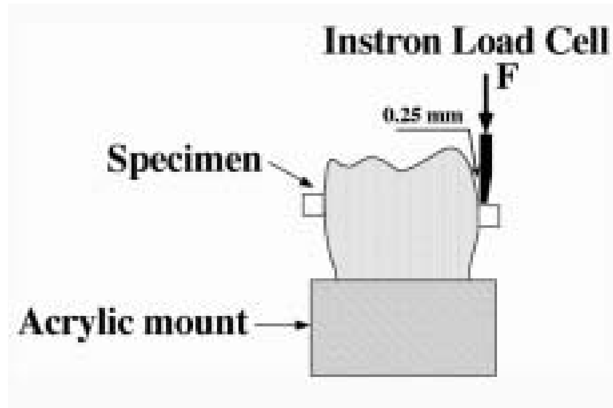

Figure 3. Shear bond strength test set-up with knife-shaped loading head oriented perpendicular to the composite cylinder.

Bond strength data was analyzed with ANOVA, with a level of significance of $P < 0.05$. Post-hoc comparisons of means were performed using *t* tests with P values adjusted for multiple comparisons (Bonferroni method).

RESULTS

The mean bond strengths and standard deviations are represented in Figure 4. In general, laser groups showed higher dentin shear bond strengths than the bur cut control groups. The laser cut without etch were statiscally significantly higher ($p < 0.05$) than the bur cut control groups. There was no statistically significant difference between etched and non-etched laser groups. Although means were higher for the non-etched laser groups compared to etched laser and control groups, there was no statistically significant difference found ($p > 0.05$). Further, no significant differences were found between PQ1 and Prime and Bond NT dentin bonding agents. The L PQ1 group revealed the highest mean shear bond strength with 17.7 ± 3.3 MPa.

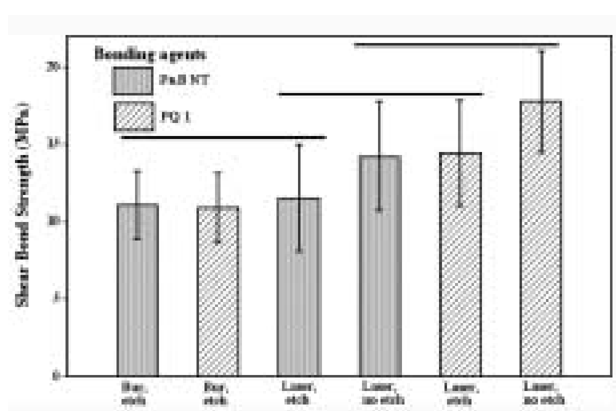

Figure 4. Summary of shear bond strength data. Vertical lines represent ± one standard deviation. Groups not statistically significantly different ($p > 0.05$) are connected by horizontal lines.

DISCUSSION

Many researchers have suggested the use of different types of lasers as an alternate to dentin conditioning.[6,7,20,27] According to some of these investigations and SEM analysis, lased enamel or dentin surfaces produced a rough surface with recrystallization, and a lack of a smear layer.[7,15,18-20,27] Although SEM was not used in this investigation, surface roughness was observed after laser ablation on all surfaces using light microscopy. This correlates with Hossain and Nakamura's study which found a significant increase in surface roughness when using the Er,Cr:YSGG laser system when compared to bur groups.[28] This increase in surface roughness may be one explanation for the higher dentin shear bond strengths for lased groups seen in this study. This surface roughness most likely lends itself to an increase in micromechanical retention at the resin-dentin interface. These highly irregular surfaces without a smear layer may provide a suitable surface for good adhesion to composite resin as reported in the previous studies using the Er:YAG and Er,Cr:YSGG lasers.[7,28,29]

With regards to the setting of the laser unit, the technique utilized in this study was to do gross reduction of the tooth structure at the recommended setting of 4 and 5 W. As the operator completed the preparation, the surface for bonding was then prepared by setting the unit at 0.75 W (53.1 J/cm^2). Some clinicians may choose to prepare the bonding surface by utilizing the same power setting as in the gross reduction of the tooth and place the fiber tip positioned in a defocused mode. This technique and its effect on bonding was not evaluated here and may be tested at a later study.

Although some generalizations can be made regarding permanent and primary tooth dentin bond strengths, there are inherent chemical and morphological differences in primary dentin that have been cited in the literature.[3,5,30] According to Sumikawa et.al., the numerical density of tubules in primary teeth is greater than that of permanent teeth.[5] This decrease in solid dentin may cause the significant differences in bond strengths that normally occur. Primary tooth dentin also has larger tubule diameters with peritubular dentin at least as thick as permanent dentin. With acid etching, there may be less solid dentin available for bonding thus leading to a decrease in bond strength relative to that of permanent teeth.[5] Due to reduced mineral content of primary dentin compared to permanent dentin, a different effect of acid conditioning has been suggested as a reason for lower bond strengths.[1] It could be possible that a larger number of tubules with a larger diameter could result in deeper penetration of the conditioner and lead to further increase in demineralization.[31] Another investigation found that the hybrid layer in primary teeth was thicker than the hybrid layer formed in permanent teeth and also found a lack of infiltration of resin into the dentinal tubules.[30] These observations may help to explain the differences in bonding to primary and permanent dentin and the importance of continuing research in this area to improve primary dentin bond strengths.

The results of this study are consistent with a previous investigation which compared permanent enamel and dentin shear bond strengths using an Er:Cr:YSGG hydrokinetic laser.[7] This study utilizing permanent dentition also found no significant differences in shear bond strength between bur and laser cut groups.The present investigation used a similar experimental design method of testing shear bond strength of composite resin. According to this study, etching the primary dentin after laser preparation with Er:Cr:YSGG laser is not necessary.

In addition, lasers may be able to eliminate or decrease discomfort associated with auditory or vibratory irritation. Although more investigation is needed in this area, a study by Matsumoto, Hossain et. al. showed that 90% of patients did not require local anesthesia during cavity preparation,[32] while an investigation by Hadley et. al. revealed that 98.5% of patients undergoing caries removal via an Er,Cr:YSGG hydrokinetic laser were treated without discomfort.[2] As reported by Jacobson et. al., not requiring dental injections may be a helpful added benefit when using this laser in the management of the young pediatric dental patient.[33]

CONCLUSIONS

The results suggest that primary dentin surfaces treated with an Er,Cr:YSGG hydrokinetic laser, with or without etching, may provide comparable or increased composite resin bond strengths depending upon bonding agent used.

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Fluoride Varnish Use in Primary Care: What do providers think?

Lewis, C. et al. Pediatrics 115: e69-e76, jan. 2005

Some state Medicaid programs reimburse pediatricians and other pediatric health care providers to apply fluoride varnishes to children who need it. A study was conducted on 12 community-based medical practices who received fluoride varnish training for 18 months.

The authors concluded that fluoride varnish can be successfully introduced into primary care physician practices, also allowing professionals the possibility of discussing pediatric preventive oral health related issues with parents.

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