RESEARCH ARTICLE

# Shear Bond Strength of Glass Ionomer Cement to Er, Cr:YSGG Laser-irradiated Dentin in Primary Teeth: An *In Vitro* Study

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## Abstract

**Background:** The clinical success of restorative materials depends upon a good adhesion with the dentinal surface to resist various dislodging forces acting within the oral cavity. Shear bond strength is the resistance to forces that slides restorative material past tooth structure. The Er, Cr:YSGG pulsed laser irradiation may be used to prepare enamel, dentin, cementum, and bone effectively and cleanly without leaving a smear layer.

**Aim:** To compare the shear bond strength of GIC to dentin treated with conventional cavity conditioning and laser irradiation methods.

**Methodology:** Thirty samples of noncarious human primary molars which get exfoliated either due to physiologic reasons or extracted due to any therapeutic reasons were collected for the study. Occlusal enamel was removed and teeth were then embedded in self-cured acrylic mold. All the prepared specimens were disinfected with Chloramine T solution and stored in distilled water for 24 hours at room temperature and teeth were randomly divided into the following groups; group 1: conventional cavity conditioning and type IX GIC restoration, group 2: Er, Cr:YSGG conditioning and type IX GIC restoration. Specimens were then subjected to thermocycling and shear bond strength was evaluated using the Lloyd testing machine.

**Statistical analysis:** One-way ANOVA test followed by Tukey's HSD *post hoc* analysis was used to compare mean shear bond strength between two study groups. The level of significance [*p*-value] were set at $p < 0.05$.

**Result:** Conditioning the dentin surface with Er, Cr:YSGG laser can increase the shear bond strength of glass ionomer restoration than conventional cavity conditioning.


**Keywords:** GIC, LASER, Shear bond strength.

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## Introduction

Glass ionomer cement was developed with the objective to produce a restorative material that would possess the desirable properties of silicate cement and polycarboxylate cement. It was first developed by Wilson and Kent. Even though conventional GIC's has properties that makes them a useful restorative material it has got some drawbacks like low wear resistance, less fracture toughness, increased chance of moisture attack, etc. These limitations of conventional GIC were overcome by GC Fuji IX, which was developed especially for Geriatric and Pediatric patients and possess improved qualities like high strength, better wear resistance, fluoride release, and chemomechanical adhesion. The clinical success of restorative materials depends upon a good adhesion with the dentinal surface to resist various dislodging forces acting within the oral cavity. Among such forces, shear stress is the force that tends to resist the sliding movement of the restoration. It is important for the restorative material clinically because the shearing effect has a major role at the tooth restoration interface. As a result, when shear bond strength is more, better will be the properties of restoration.[1]

One of the methods to improve the shear bond strength of GIC is to remove the smear layer.

A smear layer is a layer of debris on tooth surfaces formed when a tooth is cut with rotary or hand instruments. It may consist of bacteria, saliva, blood cells, dentin debris.[2] Conventional method of cleaning the dentin surface and removing the smear layer is done by using 10% polyacrylic acid prior to the application of GIC-based restorative materials. Apart from removing the smear layer, it decalcifies the dentin surface to a depth ranging from 0.5–0.1 µm and creates a mechanical interlocking through the process of hybridization. A chemical bond is created due to the ionic exchange between the carboxylic group of polyacrylic acid and the calcium ions. Thus polyacrylic acid increases the bond between GIC and tooth structure for added longevity.[3]

One of the latest and improved methods of dentin conditioning is the use of Laser.

Light amplification by stimulated emission of radiation also called Laser, is used in different fields of dentistry. Laser conditioning of enamel or dentin creates an anfractuous surface and open dentin tubules, which are ideal for adhesion.[4] The surface produced by laser etching is acid-resistant. Irradiation of laser on dental hard

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tissues modifies the calcium-to-phosphorus ratio. It reduces the carbonate-to-phosphate ratio and leads to the formation of more stable and less acid-soluble compounds. As a result susceptibility to acid attack and caries will decrease.[5]

A member of Er laser family, i.e.: erbium, chromium:scandium, gallium, garnet (Er.Cr:YSGG) was introduced with a wavelength of 2780 nm, 20 Hz frequency, and pulse energy that ranges from 0–300 mJ. Er, Cr:YSGG pulsed laser used with an air-water spray may be used to prepare enamel, dentin, cementum, and bone effectively and cleanly without leaving a smear layer. This laser doesn't produce heat or vibration and can be handled easily which makes the treatment attractive and effective.[6] Despite the efficiency of the laser, the bond strength of restorative material to tooth substrate prepared by erbium laser is often confusing and contradictory. As a result, the purpose of this study is to compare the shear bond strength of GIC to dentin that has been treated with a traditional cavity conditioner and dentin that has been laser irradiated.

## Materials and Methods

The current research was conducted on the extracted noncarious human primary molars. The study included 30 samples of noncarious human primary molars that were exfoliated either due to physiologic reasons or because they were advised for extraction due to any therapeutic reasons.

### Inclusion Criteria

- Noncarious primary molars.

### Exclusion Criteria

- Carious teeth
- Hypoplastic or developmental defects
- Teeth with restorations.

*Sample preparation*: Tissue debris and calculus were removed with a scaler underwater. After that, the teeth were placed in a 0.5% chloramine T solution for 1 week and later in normal saline solution at room temperature. Occlusal enamel was removed using a standard high-speed dental handpiece (NSK) using a water-cooled diamond disc. To guarantee that no enamel remained, they were examined under a stereoscopic microscope. Teeth were then inserted in a 2 cm × 1 cm self-cured acrylic mould and were then randomly divided into two groups after being preserved in distilled water for 24 hours at room temperature (Fig. 1).

**Fig. 1:** Tooth specimens embedded in acrylic mould

- **Group 1:** Conventional cavity Conditioning and Type IX GIC Restoration

In this group, the primary dentin was conditioned using a cavity conditioner 10% polyacrylic acid (GC conditioner), for 10 seconds, washed with water for 10 seconds, and gently air dry it. Then, according to the manufactures instructions, type IX GIC (GC Corporation, Tokyo, Japan) was applied to the dentin surface to evaluate the shear bond strength (Figs 2A to C).

- **Group 2**: Er, Cr:YSGG Conditioning and Type IX GIC Restoration

The Er, Cr:YSGG laser was used to condition primary dentin at 9 J/cm$^2$, 0.5W average power, and 25 mJ/pulse. During irradiation, the water spray level was set at 6, and the sapphire tip was kept 2 mm away from the target surface. Then, according to the manufactures instructions, type IX GIC (GC Corporation, Tokyo, Japan) was applied to the dentin surface (Figs 3A and B).

### Thermocycling

Immediately after restoration, teeth were transferred into separate labeled containers filled with distilled water. Specimens were thermocycled for 500 cycles at temperatures ranging from 5–5 degrees Celsius for 60 seconds.

### Shear Bond Strength Test

Teeth to be tested for their shear bond strength were kept in distilled water for 2 days after thermocycling. It was then subjected to a Universal testing machine (fine testing machine) with a crosshead speed 1 mm/minute using a knife-shaped head in a compression mode. ANOVA TEST was used to examine bond strength data, with a significance of $p < 0.05$ (Figs 4 and 5).

## Statistical Analysis

To compare mean shear bond strength between the two study groups, a one-way ANOVA test was utilized, followed by Tukey's HSD *post hoc* analysis. The significance threshold [*p*-value] was set to $p < 0.05$.

## Results

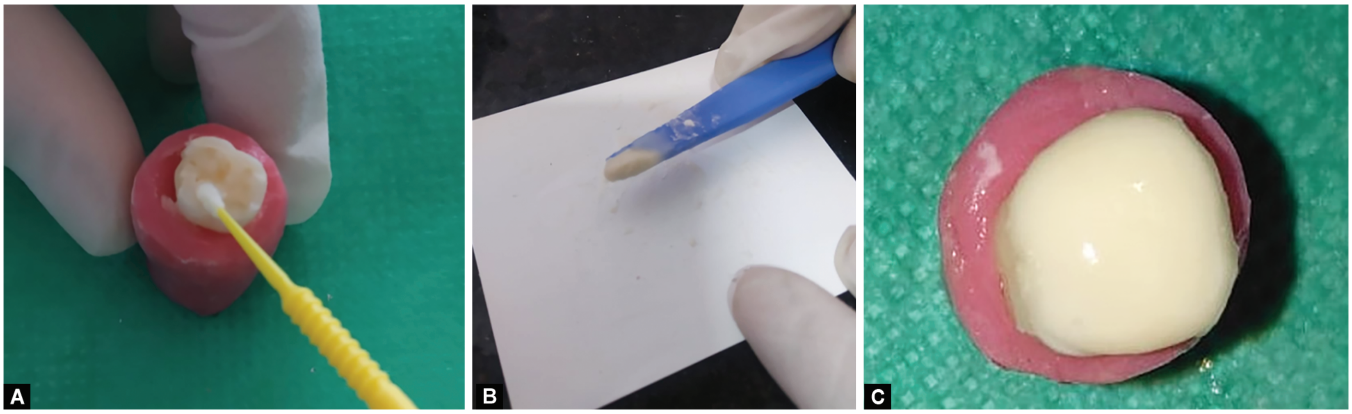
(Table 1 and Fig. 6)

Comparison of bond strength was done between two groups in which one group was conditioned with polyacrylic acid and another group was laser conditioned and both groups were then restored with Type IX GIC. A total number of 15 samples were analyzed in each group. The findings of the *t*-tests revealed that bond strength of type IX GIC was significantly increased (*p* 0.0001) with laser conditioning, whereas bond strength of type IX GIC with conventional cavity conditioning (10% Polyacrylic acid) was significantly lower. These data are summarized in Figure 6.

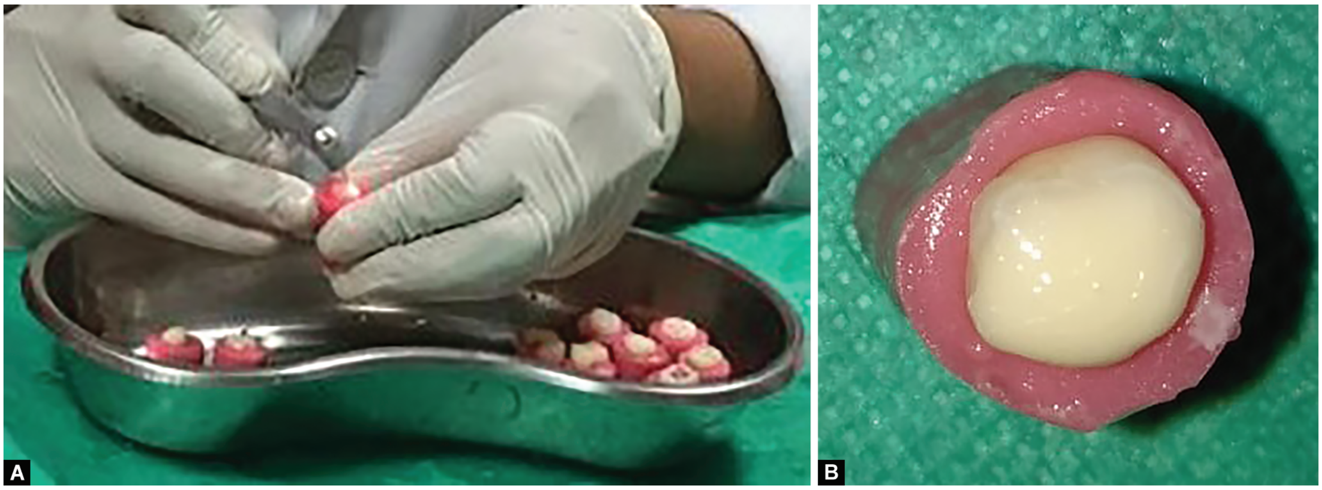
The change in mean shear bond strength was statistically significant (*p* value 0.0001), indicating that using the Er, Cr:YSGG laser to modify the dentin surface can improve the shear bond strength of glass ionomer restorations.

## Discussion

The primary goal of dentin conditioning is to eliminate the smear layer and improve the wettability of the tooth surface. The adhesion of adhesive materials to the tooth substrate should result in a packed and mixed structure of collagen fibrils and



**Figs 2A to C:** (A) GC conditioner applied, (B) Manupulation of GIC done, (C) Restored with GIC



**Figs 3A and B:** (A) Dentin irradiated with Er, CR:YSGG LASER, (B) Restored with GIC

**Fig. 4:** Universal testing machine: Fine testing machine

restorative material components that is impervious to oral and dentinal fluids.[3]

Polyacrylic acid is the GC conditioner used conventionally to condition the dentin surface. In the setting reaction of GIC, provides a carboxyl group for hydrogen bonding and improves the interaction of polar and ionic attraction.

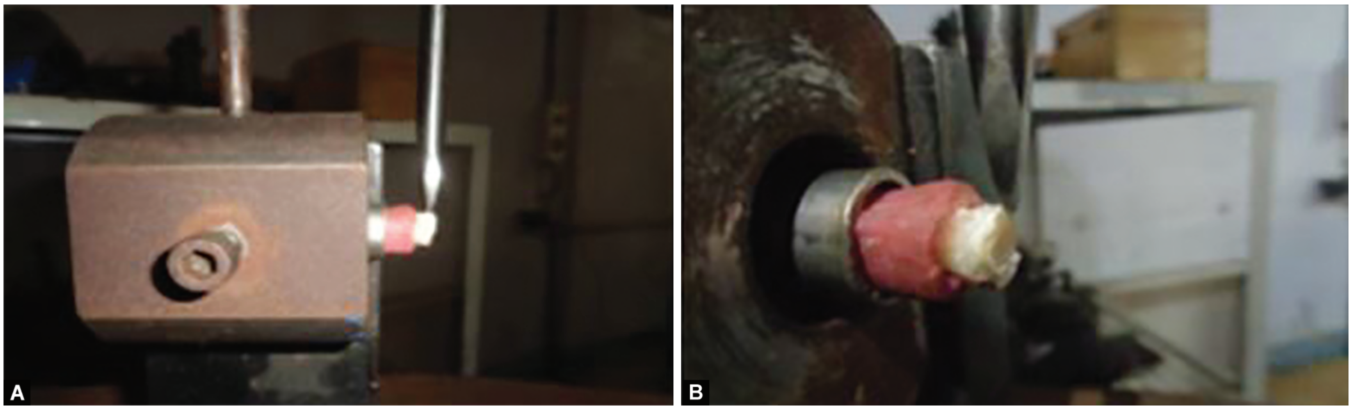
In the field of new technology, the conditioning of dentin surfaces with a laser has become widespread.

Er, Cr:YSGG laser which comes from Er family shows efficient cutting and conditioning of dental hard tissues.

Histological studies have shown that teeth treated with this laser produce no inflammatory response to a pulp. The Er, Cr:YSGG laser increases the amount of calcium and phosphorous in the compound, making it less acid-soluble and more stable. This will reduce the amount of acid that attacks the tooth surface.[7]

In this study, the test result demonstrated that the group with Laser conditioning has significantly higher mean shear bond strength (3.381 ± 0.088) as compared to the group with conventional conditioning (3.033 ± 0.065) (this mean difference of –0.347 (95% CI, –0.347 to –0.405) between two groups is statistically significant at $p < 0.001$).

The increased shear bond strength of laser-conditioned dentin teeth is most likely due to the removal of the smear layer and an improvement in the wettability of the dentin surface, both of which are compatible with traditional GICs. Also, laser irradiation causes water loss from collagen fibrils, lowering the hydrophilicity of the dentin substrate, which is suitable for hydrophobic restorative materials like GICs.



**Figs 5A and B:** Glass ionomer cement block dislodged

**Table 1:** Comparison of mean shear bond strength (in MPa) between 02 study groups using independent student *t*-test

| | | | | | *95% Conf. interval* | | | |
|---|---|---|---|---|---|---|---|---|
| *Group* | *N* | *Mean* | *SD* | *Mean diff* | *Upper* | *Lower* | *t* | *p-value* |
| Group 1: Conventional conditioning and type 9 GIC restoration | 15 | 3.033 | 0.065 | −0.347 | −0.405 | −0.289 | −12.265 | <0.001* |
| Group 2: Er, Cr:YSGG conditioning and type 9 GIC restoration | 15 | 3.381 | 0.088 | | | | | |

*Statistically significant

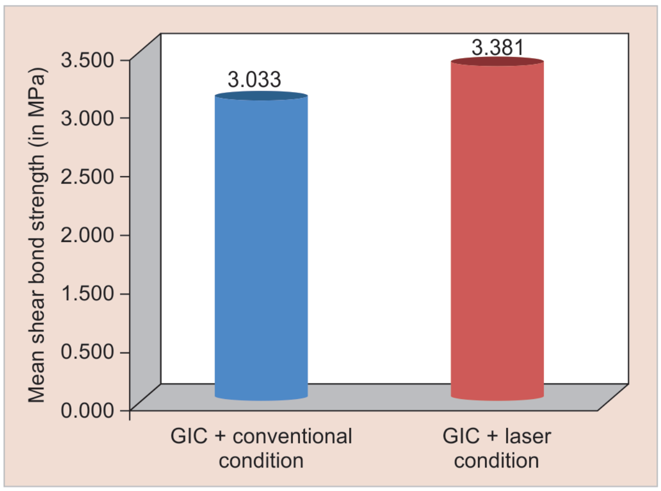



**Fig. 6:** Comparison of mean shear bond strength (in MPa) between two study groups

The bond strength of laser-treated dentin surfaces has been found to enhance due to the absence of the smear layer and the opening of the dentinal tubules, which resulted in an uneven surface.[2] An in vitro study conducted by Garbui et al. concluded that laser irradiation using an energy density of 9 $Jcm^2$, with the power of 0.5 W, and 25 mJ pulse provide the most appropriate specifications for dentine surface conditioning before the use of conventional GIC.[8]

Another study conducted by Navimipour et al. concluded that surface treatment of GIC using 35% phosphoric acid or Er, Cr:YSGG laser may increase the shear bond strength of GIC to composite resin and improve fracture mode while in RMGIC only laser etching resulted in significantly higher bond strength.[9]

Another *in vitro* study conducted by Ekworapoj et al. was concluded that the bond strength between GIC and dentin was shown to be unaffected by laser preparation alone but improved by using laser-irradiated dentin in combination with a dentin conditioner.[10] A study conducted by Jordehi et al. found out that the bond strength of Conventional GIC is dramatically reduced when dentin is irradiated with an Er, Cr:YSGG laser at a power of 1.0 W, 50 mJ/pulse, 65% air pressure, and 55% water pressure.[7] The most effective conditioner, according to Powis et al., is acrylic acid. This acid is gentle on dental tissues and eliminates the smear layer and surface contaminants without excessive opening the dentinal tubules.[11]

According to the current findings, Er, Cr; YSGG laser improves the bond strength to type IX GIC. Although the study was statistically significant, more research with larger sample size, as well as additional laser parameters and bonding agents that influence bond strength, should be conducted for improved therapeutic success.

## Conclusion

The results revealed that primary dentin surface treated with Er, Cr:YSGG laser provided higher bond strength to Type IX GIC (conventional cavity conditioning) compared to primary dentin treated with 10% Polyacrylic acid (conventional cavity conditioning).

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