Dentin Conditioning Using Different Laser Prototypes (Er,Cr:YSGG; Er:YAG) on Bond Assessment of Resin-modified Glass Ionomer Cement

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ABSTRACT

Aim: The aim of this study was to evaluate and compare various conditioning regimes (lased and conventional) on shear bond strength (SBS) of resin-modified glass ionomer cement (RMGIC) bonded to dentin.

Materials and methods: Sixty non-curious intact maxillary molars were cleaned, isolated, and randomly divided into six groups (n = 10). Before randomization, the dentin surface was exposed and finished. Samples in group I were conditioned using Er,Cr:YSGG laser (ECYL). Specimens in group II were conditioned using Er:YAG laser (EYL), and the dentin surfaces of specimens in group III and group IV were conditioned using cavity conditioner and K930. Similarly, the samples in group V and group VI were surface treated using 17% EDTA and total etch. All samples were bonded with RMGIC following conditioning regime. For SBS testing, the samples were placed in universal testing machine. A fracture analysis of debonded surfaces was evaluated using stereomicroscope at 40x magnification. Means and standard deviations (SDs) were calculated using analysis of variance (ANOVA) and Tukey’s post hoc test at a significant level of p < 0.05.

Results: The maximum bond strength values were observed in group VI total etch (23.85 ± 3.67). The lowest bond strength was displayed in lased dentin group II conditioned by EYL (11.65 ± 2.77). Dentin conditioned with ECYL, cavity conditioner, K930 conditioner, and 17% ethylenediaminetetraacetic acid (EDTA) were found to be comparable, p > 0.05. Cohesive failure was dominant among experimental groups.

Conclusion: Er,Cr:YSGG laser has a potential to be recommended for dentin conditioning prior to application of RMGIC.

Clinical significance: Dentin conditioning enhances adhesion of RMGIC for improved prognosis and treatment outcome.

Keywords: Bond integrity, Er,Cr:YSGG, Er:Yag, Resin-modified glass ionomer cement, Surface conditioning.

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INTRODUCTION

Premature restorative failure is a foremost concern in clinical dentistry. The failure is a reason of weak bond between the substrate and restorative interface resulting in poor prognosis and treatment outcome. The goal to find an ideal restorative material led to the evolution of resin-modified glass ionomer cement (RMGIC). A typical RMGIC consists of 80% fluoro-aluminium silicate glass in the form of glass ionomer cement (GIC) with polyacrylic acid (PAA) and 20% light-polymerized resin hydroxy-ethylmethacrylate (HEMA) or bisphenol A-glycidyl methacrylate (Bis-GMA) in the form of methacrylate.

Resin-modified glass ionomer cements are hybrid materials and have characteristics better than conventional GIC. The properties of RMGIC range from better esthetics, improved handling, increased working time, and higher moisture resistance. However, a controversy exists in the literature regarding the adhesion of GICs to dentin. Some studies suggest that RMGIC adheres to the tooth physiochemically without the need of conditioning, whereas other studies have stated that conditioning of dentin is necessary to improve bond strength values.

Dentin conditioners in the form of PAA, cavity conditioners, phosphoric acid, and EDTA have been documented to improve bond durability and strength when applied prior to RMGIC. The use of conditioners removes smear layer, demineralizes, and makes dentin surface more receptive for bonding. Moreover, conditioning favors bonding of RMGIC with dentin both mechanically and chemically.

Alternatively, the use of ECYL and EYL for enamel/dentin physiochemically without the need of conditioning, whereas controversy exists in the literature regarding the adhesion of GICs to dentin. The failure is a reason of weak bond between the substrate and restorative interface resulting in poor prognosis and treatment outcome. The goal to find an ideal restorative material led to the evolution of resin-modified glass ionomer cement (RMGIC).

To our knowledge from indexed literature, scarce evidence exists on the use of ECYL and EYL as dentin conditioner bonded with RMGIC. Moreover, limited data on comparison of conventional conditioning regimes with ECYL and EYL have been documented. It is hypothesized that dentin conditioned with cavity conditioner (control) prior to RMGIC will exhibit bond strength values comparable with ECYL and EYL. Therefore, the aim of this study is to evaluate and compare various conditioning regimes (lased and conventional) on shear bond strength (SBS) of resin-modified glass ionomer cement (RMGIC) bonded to dentin.

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was to evaluate and compare various conditioning regimes (lased and conventional) on SBS of RMGIC bonded to dentin.

**MATERIALS AND METHODS**

Sixty non-carious, unrestored, intact maxillary third molars were collected in a period of 1 year as a bonding substrate and were stored in 0.4% sodium azide solution (NaN₃) (Merck, Germany). The specimens were cleaned with periodontal scaler and curette (Perio Soft-Scaler; Kerr Dental, Denmark) to remove debris and inorganic remnants and stored in chloramine T trihydrate solution (Merck) for 1 week following storage in distilled water at 4°C until use.

The specimens were embedded vertically in self-cure acrylic resin (Opti-cryl, South Carolina, Columbia) up to cement–o–enamel junction within polyvinyl pipes of 4 mm diameter. Model trimmer (IsoMet; Buehler, USA) under irrigation was used to wet ground the occlusal surface, to expose dentinal surface finished with silicon carbide grinding disks 1,200 grits (Buehler, Great Britain, UK). Based on the conditioning regimes, the samples were randomly classified into six groups (n = 10 each).

- **Group I:** The samples were conditioned with ECYL (Waterlase; Biolase Technology, San Clemente, CA) at 0.5 W and 30 Hz frequency from 2 mm distance in a noncontact position for a duration of 60 seconds using a laser tip M2B. The air/water pressure was 65%/55%.
- **Group II:** The surface of bonded specimen was treated using EYL (Kavo Key Laser 2; Kavo Corp., Biberach, Germany). The laser was used in a circular motion at 350 mJ of energy and 2 Hz of pulse repetition for a duration of 60 seconds at 2 mm distance.
- **Group III:** The surface of the samples was conditioned using a cavity conditioner (GC America, Inc, Latin America) applied for a duration of 10 seconds and washed and air-dried without desiccation.
- **Group IV:** Bonded dentinal surface of specimens was conditioned using K930 conditioner (GC America, Inc, Latin America) for 15 seconds and washed and air-dried for 3 seconds without desiccation.
- **Group V:** Dentinal surface of the specimens was surface treated with 17% EDTA (Pyrex Pharmaceutical, USA) for 30 seconds and washed for 15 seconds and blow-dried without desiccation.
- **Group VI:** All samples in this group were exposed with 37% phosphoric acid (Aquacryl, India) for 10 seconds and rinsed thoroughly for 10 seconds. Bonding agent (Prime & Bond NT; Dentsply, Sirona, USA) was applied for 10 seconds and light-cured (Bluephase G2; Ivoclar Vivadent, Schaan, Liechtenstein) 10 seconds.

All samples were now bonded with RMGIC Fuji II LC (GC Corporation, Tokyo Japan) and mixed and applied incrementally (2-mm-thick increment) in accordance with the manufacturer’s instructions and light cured for 20 seconds (Bluephase G2; Ivoclar Vivadent). A protective varnish was applied, and the specimens were stored in distilled water for 24 hours followed by SBS testing (Table 1).

**SBS Testing of Specimens**

Specimens were placed at the lower base of universal testing machine (Lloyds LF-Plus; Ametek, Inc., Great Britain, UK) so that the bonded base cylinder was parallel to the direction of force at 0.5 mm/minute crosshead speed until fracture. The load required to debond was recorded in Newton but calculated in megapascals.

### Table 1: Materials used in this study

| Materials          | Manufacturer                     | Composition                                                                 |
|--------------------|----------------------------------|------------------------------------------------------------------------------|
| Fuji II LC         | GC Corporation, Tokyo Japan      | Fluoro-aluminium silicate glass, polyacrylic acid, HEMA                     |
| Cavity conditioner | GC America, Inc.                 | 20% polyacrylic acid, AlCl₃                                                 |
| K930 conditioner   | GC America, Inc.                 | 12% citric acid, 4% AlCl₃                                                   |
| 17% EDTA           | Pyrex Pharmaceutical             | 17% poly-amino carboxylic acid                                              |
| Optibond Solo Plus | KaVo Kerr, West Collins, Orange, CA| Bisphenol glycidyl methacrylate, glycerol DMA, glycerol phosphate DMA, DMAs, ethanol silicone oxide, barium borosilicate, and sodium hexafluoro-silicate |

**Fracture Analysis**

Fracture surfaces of debonded specimens were analyzed under stereomicroscope (SR; Zeiss, Oberkochen, Germany) at 40× magnification by a single examiner to minimize bias. The modes of failure of samples were classified into adhesive (substrate–adhesive interface), cohesive (in the materials or in substrate itself), and adhesive (involving both interfaces of material and substrate). Failure sites were not statistically examined.

**Statistical Assessment**

Normality of the data were assessed using Kolmogorov–Smirnov test, and equality of variance assumptions was evaluated by modified Levene test. Means and standard deviations were calculated using ANOVA and Tukey’s post hoc test at a significant level of p < 0.05.

**RESULTS**

Normal distribution of data was observed in this study. For bond strength values, ANOVA showed a significant difference among all the experimental groups (p < 0.05). The maximum bond strength values were observed in group VI total etch (23.85 ± 3.67). The lowest bond strength was displayed in lased dentin group II conditioned by EYL (11.65 ± 2.77). Dentin conditioned with ECYL in group I, cavity conditioner in group III, K930 conditioner in group IV, and 17% EDTA in group V was found to be comparable, p > 0.05 (Table 2 and Fig. 1).

Fracture analysis of debonded specimen revealed cohesive failure among group I, group III, group IV, group V, and group VI. Moreover, the adhesive failure type was observed in group II conditioned with EYL (Table 3 and Fig. 2).

**DISCUSSION**

The present laboratory-based study was constructed on the hypothesis that conventional conditioning of dentin using cavity conditioner will exhibit bond integrity similar to lased dentin (ECYL and EYL). Interestingly, the present in vitro study revealed that conditioning of dentin with ECYL exhibited comparable SBS with
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Dentin conditioned with 17% EDTA, cavity conditioner, and K930 conditioner. While dentin conditioned with EYL displayed low bond integrity with RMGIC. Therefore, the hypothesis of this study was partially accepted. In this study, the SBS values were assessed using a universal testing machine as the method is homogeneous, easy to use, and displays quantitative data for comparative analysis. Furthermore, the test is beneficial for depth profiling and screening of RMGIC and GIC.17,18

The bonding of restorative material to dentin structure is complex. Conditioning of dentin preceding RMGIC modifies the dentin by making it receptive to bond, eliminates smear layer, and enhances surface wettability.11 In this study, dentin conditioned with EYL exhibited the lowest bond strength (11.65 ± 2.77) among all investigational groups. Er:YAG laser is well absorbed by the dental tissues and the wavelength on which EYL works coincide with absorption band of water (approximately 3 μm) and hydroxyapatite crystals of dentin.12 Evidence dictates that low bond scores shown by EYL can be attributed to heat production resulting in structural damage to dentin.19,20 Moreover, excessive heat may result in denaturation of the collagen network preventing diffusion of monomer compromising bond integrity.12 It can be also estimated that thermal effect by EYL may compromise interdiffusion zone formation between RMGIC and dentin substrate.20,21 The finding of low bond score by EYL in this study was in harmony with the work by De Souza-Gabriel et al.19 However, studies by Hibst and Keller22 and Visur et al.23 argue that heat produced by EYL does not damage the dentin and propagates into pulp. In contrast, conditioning of dentin with ECYL (18.25 ± 3.22) exhibited bond strength comparable with cavity conditioner (17.54 ± 2.93), K930 (18.33 ± 2.52), and 17% EDTA (19.25 ± 3.21). A possible explanation to this finding of no significant difference was found with cavity conditioners (17.54 ± 2.93), K930 (18.33 ± 2.52), and 17% EDTA (19.25 ± 3.21) with Fuji II LC. It has been demonstrated in previous studies that PAA in the form of cavity conditioner enhanced bond strength by creating irregularities on the substrate surface and AlCl3 in cavity conditioner stabilized dental collagen for easy penetration of HEMA in RMGIC during dentin demineralization.5,26 Moreover, citric acid used as dentin conditioning agent was first used by Hotz et al.27

Table 2: Using analysis of variance (ANOVA) and Tukey’s multiple comparison test for the comparison of means and SD for bond strength values among study groups.

| Material type                  | Type of conditioning          | Mean ± SD   | p value* |
|-------------------------------|-------------------------------|-------------|----------|
| Fuji II LC (RMGIC)            | Group I: Er,Cr:YSGG laser (ECYL) | 18.25 ± 3.22a | < 0.05   |
|                               | Group II: Er:YAG laser (EYL)   | 11.65 ± 2.77b |          |
|                               | Group III: cavity conditioner (control) | 17.54 ± 2.93a |          |
|                               | Group IV: K930 conditioner     | 18.33 ± 2.52a |          |
|                               | Group V: 17% ethylenediaminetetraacetic acid (EDTA) | 19.25 ± 3.21a |          |
|                               | Group VI: total etch           | 23.85 ± 3.67c |          |

Different superscript letters in individual materials indicate statistical differences (p < 0.05); *Showing significant difference among study group (ANOVA)

Fig. 1: Line chart displaying shear bond strength among the investigational groups. Group I, Er,Cr:YSGG laser (ECYL); group II, Er:YAG laser (EYL); group III, cavity conditioner (control); group IV, K930 conditioner; group V, 17% ethylenediaminetetraacetic acid (EDTA); group VI, total etch

dentin, form of dentin (human or bovine), irradiation time and distance, and type of material.

Dentin conditioned with 17% EDTA displayed mean bond strength value of 19.25 ± 3.21. A possible explanation to this outcome can be ascribed to its less aggressive nature to decalcify dentin creating low and thin resin tags, widening of dental orifice, and formation of thin hybrid layer without dissolving dentinal proteins.21 This analysis is validated by Rai et al.6 asserting that 17% EDTA used as a conditioner on dentin presented better bond integrity with three different types of RMGIC. The highest bond strength values were noted in the total etch group. This outcome was in concurrent with the work by Poggio12 and Imbery et al.2 Improved removal of smear layer and better opening of dentinal tubules resulting in effective penetration of resin monomer forming a healthier diffusion zone between dentin and cement ensuing both mechanical and chemical interlocking are some factors contributing to highest bond scores in this group.
Majority of failure type among experimental groups was cohesive. While adhesive failure was noted in the EYL group only. The type of failure in different experimental groups corresponded to SBS scores. Cohesive failure is found to be common in RMGIC due to porosity within the cement itself. It is expected that these porous areas within the material act as stress concentrators from where the fracture is instigated.

Within the limitations of this study, the greatest drawback of the current in vitro study was not performing micromorphological evaluation of the conditioned dentin surface and dispersive spectroscopy of the debonded surface. The concept of conditioning dentin with different laser prototypes is a novel concept and needs further clinical and lab-based evaluation under different dentin with different laser prototypes is a novel concept and needs further clinical and lab-based evaluation under different conditions. The Journal of Contemporary Dental Practice, Volume 21 Issue 4 (April 2020)

Table 3: Percentage distribution of modes of failure

| Failure type (%) | Group I: Er,Cr:YSGG laser (ECYL) | Group II: Er:YAG laser (EYL) | Group III: cavity conditioner (control) | Group IV: K930 conditioner | Group V: 17% EDTA | Group VI: total etch |
|------------------|----------------------------------|-----------------------------|----------------------------------------|---------------------------|---------------|-------------------|
| Adhesive         | 10                               | 80                          | 20                                     | 10                        | –             | 20                |
| Cohesive         | 60                               | 10                          | 50                                     | 70                        | 60            | 70                |
| Admixed          | 30                               | 10                          | 30                                     | 20                        | 40            | 10                |

Fig. 2: Multiple bar chart showing fracture analysis among different groups. Group I, Er,Cr:YSGG laser (ECYL); group II, Er:YAG laser (EYL); group III, cavity conditioner (control); group IV, K930 conditioner; group V, 17% ethylenediaminetetraacetic acid (EDTA); group VI, total etch

Conclusion

ECYL has a potential to be recommended for dentin conditioning prior to application of RMGIC.

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