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# Debonding Resistance of Various Glass Ionomer Cements to Saliva-Contaminated Dentin: An in vitro Study

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## Abstract

**Background:** Glass ionomer cements (GICs) are widely used in dentistry as they can effectively bond to the tooth structure and release fluoride ions. However, saliva contamination during the setting process can impair bond strength and reduce the longevity of the restoration.

**Aim:** To evaluate the debonding resistance of different glass ionomer cements with saliva-contaminated dentin.

**Materials and methods:** Forty-five extracted human premolar teeth were embedded in an acrylic block. The teeth were sectioned until the dentin surface was exposed and contaminated with saliva. Then, the Poly-tetra-fluoro-ethylene tube was placed on the dentin surfaces of the specimens, and the different glass ionomer cement mixes, type IX GIC, resin-modified GIC (RMGIC), and hybrid GIC, were condensed into it. The specimens were subjected to 500 cycles of thermocycling for 20s at 5º to 55º temperature and were stored in distilled water for 10 days. Debonding resistance of the specimens was measured using a universal testing machine (UTM). The specimen was mounted on the UTM, and the load was applied at a crosshead speed of 1 mm per minute until debond occurs. The obtained data was subjected to one-way ANOVA analysis followed by post-hoc analysis.

**Results:** Light-cure RMGIC showed the highest debonding load (45.358 ± 15.171 N), followed by Type-IX GIC (8.048 ± 3.717 N) and Hybrid GIC (7.574 ± 3.501 N). One-way ANOVA showed significant differences among groups (p=0.000). The pair-wise comparison revealed light-cure RMGIC differed significantly from Type-IX and Hybrid GIC (p=0.000), while Type-IX and Hybrid GIC showed no significant difference (p=0.989).

**Conclusion:** Light-cure RMGIC exhibited superior debonding resistance compared to Type-IX and Hybrid GICs.

**Keywords:** Glass Ionomer cement, Shear bond strength, Saliva-contamination, Dentin.

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## 1. Introduction

In modern dentistry, innovative restorative materials are employed to repair tooth structures that have been damaged by various pathologies [1]. These materials should be stable, biocompatible, strong enough to sustain masticatory stresses, and closely resemble natural dentin. Glass ionomer cements (GICs) are widely used in dentistry and are recognized for their smart material properties. Davidson was the first to explore these characteristics [2]. GICs are acid-base cements formed through a chemical reaction between mild polymeric acids and powdered glasses. Their setting mechanism involves concentrated aqueous solutions, with unreacted glass particles serving as fillers to enhance strength and support the cement structure [3].

Recent advancements in the physical and mechanical properties of GICs have enhanced their applications in restorative and pediatric dentistry, endodontic surgery, and dental prosthetics. However, their use remains limited to low-stress areas due to challenges such as low compressive strength, limited abrasion and fracture resistance, and moisture sensitivity during setting [4]. GICs can release fluoride, promoting tooth remineralization and helping prevent secondary caries. Recent advancements, such as nanoparticle incorporation, have further enhanced fluoride release and its associated benefits [5,6].

GICs, including Conventional, light-cured, hybrid, etc., are widely used in dentistry. Conventional GICs are further classified as high- or low-viscosity based on their liquid-to-powder ratio and ion concentrations. Hybrid GICs differ in glass particle size, which influences their mechanical and physical properties [7]. GC Advanced Glass Hybrid technology is a hand-mixed, self-adhesive posterior restorative, combining two FAS glass types with two polyacrylic acids for enhanced strength, durability, and aesthetics. Benefits include improved translucency, colour compatibility, acid resistance, moisture tolerance, and fluoride release [6].

A rubber dam is essential for preventing saliva and other fluids from compromising restorations, as it minimizes contamination and allows the dentist to focus on the procedure [8]. However, its use can be challenging in cases involving erupting or severely damaged teeth, as well as in children who breathe orally. As a result, some dentists avoid using rubber dams, increasing the risk of saliva contamination [8]. Saliva's hydrolytic enzymes can weaken the bond between restorative materials and the tooth, leading to issues like recurrent caries, sensitivity, discoloration, restoration loss, and reduced bonding effectiveness [9].

The impact of saliva contamination on the debonding resistance of different GIC types remains poorly understood, despite being a common cause of restoration failure. To address this knowledge gap, this study aims to evaluate and compare the debonding resistance of three different restorative GIC materials on saliva-contaminated dentin.

## 2. Materials and methods

This study was approved by the Institutional Ethics Committee of AJ Institute of Dental Sciences, Karnataka, India (IEC No.: IEC/ENDO22/138/V2PROCEDURE). GC Gold label Type-IX GIC (GC Corporation, Japan), GC Gold label Light-cure Resin modified GIC (RMGIC) (GC Corporation, Japan), and GC Gold label Hybrid GIC (GC Corporation, Japan) were used in the study.

### 2.1 Sample Preparation

A total of 45 freshly extracted premolar teeth, obtained for orthodontic and periodontal reasons, with intact surfaces, were collected. The extracted teeth were cleaned and stored in distilled water. Teeth with caries, cracks, restorations, discoloration, fractured crowns, hypoplastic or hypomineralized defects, or developmental anomalies were excluded from the study.

Each tooth was embedded in an acrylic resin block (17 mm diameter, 25 mm height), with the buccal surfaces flattened using a diamond bur until yellow dentin was visible. The dentin surfaces were conditioned with 10% polyacrylic acid for 20 seconds, dipped in artificial saliva for 5 seconds, and air-dried. Forty-five teeth were divided into three groups with 15 in each (n=15), based on the type of the GIC, Type-IX (Group 1), light-cure RMGIC (Group 2), and Hybrid GIC (Group 3). On the dentin surfaces in each group, a Poly tetra fluoro ethylene (PTFE) cylindrical tube was secured and the glass ionomer cements were mixed according to the manufacturer's recommendations. The GIC mixes were condensed into their respective PTFE tubes in each group and allowed to be set. The specimens were stored in distilled water for 10 days and subjected to 500 cycles of thermocycling for 20s at 5° to 55° in thermocycler (Thermal-cycler, Taurus Scientific, Ohio, USA).

### 2.2 Measuring debonding resistance

Debonding resistance was tested using the universal testing machine (Instron - 5500 series, USA). The specimen was placed on the UTM and the shear load was applied with a knife-like mandrel at the interface of the GIC and the dentin at a cross-head speed of 1.0 mm/min until debonding occurs. The debonding load was recorded in Newtons.

### 2.3 Statistical analysis

The obtained data was subjected to the statistical analysis using the statistical package for social sciences (SPSS V.30, IBM Corporation, USA). The data was subjected to one-way ANOVA analysis followed by post-hoc analysis for intergroup comparison. The p-value less than 0.05 was considered as statistically significant.

## 3. Results

The mean debonding load (N) and standard deviation is mentioned in Table 1. The maximum debonding load was observed with the light-cure RMGIC (45.358 ± 15.171 N) followed by Type-IX GIC (8.048 ± 3.717 N). The least shear debonding load was found with Hybrid GIC (7.574 ± 3.501 N). One-Way ANOVA analysis showed significant difference among the three groups of glass ionomer cements (Table 1).

**Table 1: Comparison of mean debonding load (One-way ANOVA analysis).**

| Groups | N | Debonding load (N) Mean ± SD# | p-Value |
|---|---|---|---|
| **Type-IX GIC** | 15 | 8.048 ± 3.717 | 0.000* |
| **Light-cure RMGIC** | 15 | 45.358 ± 15.171 | |
| **Hybrid GIC** | 15 | 7.574 ± 3.501 | |

#Standard deviation
*Statistically significant

Pair-wise comparison between different groups is presented in Table 2. On pair-wise comparison, light-cure RMGIC exhibited significant differences with the Type-IX GIC and Hybrid GIC (p=0.000). However, no significant difference (p=0.989) was observed in the shear debonding load between Type-IX GIC and Hybrid GIC (Table 2).

**Table 2: Pairwise Comparison of debonding load (post-hoc analysis)**

| Groups | | Mean Difference | Standard Error | Significance (p-Value) |
|---|---|---|---|---|
| **Type-IX GIC** | Light-cure RMGIC | 37.310 | 3.374 | 0.000* |
| | Hybrid GIC | 0.474 | 3.374 | 0.989 |
| **Light-cure RMGIC** | Hybrid GIC | 37.784 | 3.374 | 0.000* |

*Statistically significant

## 4. Discussion

Glass ionomer cement (GIC), introduced by Wilson and Kent in 1972, is widely used in dentistry due to its chemical bonding to dentin and enamel. GICs have physical properties similar to tooth structure, resist microleakage, and provide prolonged fluoride ion release [10]. Despite their benefits, GICs have limitations including water sensitivity during the initial setting, a long maturation period, and poor wear resistance, which restrict their use to areas with light masticatory loads [11]. To improve GIC's mechanical and physical properties, it has been modified to enhance marginal adaptability, biocompatibility, chemical adhesion, and thermal expansion similar to that of the tooth structure. Effective dentin adhesion helps prevent microleakage, marginal discolouration, secondary caries, and potential pulpal damage [12]. GC Gold Label Type-IX and GC Gold Label-II LC GICs have been extensively tested, whereas GC Gold Label Hybrid is newer and requires further mechanical testing to confirm its suitability and indications as a standard restorative material.

GIC is commonly used in Atraumatic Restorative Treatment (ART), which is often performed in non-clinical settings where the risk of saliva contamination is high. Chen CN *et al.* demonstrated that water contamination can reduce the bond strength of GIC restorations [13]. Shear bond strength is crucial for determining the longevity of restorations in the oral cavity. The present study aimed to evaluate the effect of saliva contamination on the debonding resistance of different glass ionomer materials.

The present study reported that greater loads are required to debond the RMGIC specimens from the saliva-contaminated dentin surface compared to Type IX and Hybrid GICs. A statistically significant difference in shear debonding load was observed among the three GIC groups (p=0.000). The reason for the RMGIC to exhibit high debonding loads could be attributed to its lower moisture sensitivity during the initial setting phase, aided by the hydrophilic resin.

Bhattacharya P *et al.* found that Ketac™ Molar (KM) exhibited the highest shear bond strength (SBS) to enamel and dentin and superior flexural strength (FS) compared to other ART materials, while Zirconomer and Fuji IX GP Extra (FJ) had similar SBS to dentin and enamel [14]. In contrast, Meharwade P *et al.* found that a methacrylate-based composite had superior shear bond strength compared to Type-II and-IX GICs, with reinforced GIC outperforming Type-IX GIC [15]. Somani R *et al.* reported that light-cure GIC significantly outperformed Type-IX and conventional GICs in shear bond strength, which aligns with the current study's finding that reinforced GIC has superior shear bond strength [1]. Deformation at break quantifies the extent to which a material stretches before breaking, expressed as a percentage of its original size. It indicates the material's ductility and ability to withstand deformation before failure. Higher values suggest greater ductility, which can influence the durability of restorations under chewing forces.

Shimazu K and colleagues found that artificial saliva contamination significantly decreased dentin bond strength for composite resin. GIC and resin-modified GIC showed no differences in bond strength or microleakage under various surface conditions [9]. Another study by Shimazu K *et al.* evaluated the impact of artificial saliva contamination on GIC, resin-modified GIC, and composite resin (CR) in class V restorations. They tested control, moderate, and severe contamination levels. The study found that dentin bond strength for CR significantly decreased after contamination, but no significant differences were noted in bond strengths or microleakage for GIC and resin-modified GIC [8]. This outcome also differs from the findings of the current investigation. This difference in the results may be attributed to differences in testing methodologies, material compositions, and contamination protocols. Their study primarily focused on Class V restorations, where cavity geometry and adhesive bonding dynamics may differ from flat surface bonding used in the present study. Additionally, variations in the composition of GICs, surface pretreatment, and the severity of contamination could influence bond strength outcomes.

The current study showed that light-cured GIC has superior debonding resistance compared to other GIC types, likely due to its micromechanical bonding and enhanced ion exchange [16]. Another study reported that the resin in light-cured GIC improves initial strength, and fracture toughness, and reduces solubility. Benefits include faster setting, lower moisture sensitivity, extended working time, and rapid hardening upon light exposure [17].

A recent study by Gadekar SV *et al.* found that applying SDF significantly increased the shear bond strength of type IX GIC in all four treatment groups, indicating that SDF positively enhances the durability of restorations [18]. However, a different study concluded that SDF application did not affect the shear bond strength of restorative materials [19]. This avenue can be considered a foundation for future studies to ascertain different ways to improve the shear bond strength of GIC.

This in-vitro study has limitations, as real-oral environment and treatments involve more factors than saliva contamination. Storing samples in water may have affected dentin permeability, limiting comparison with in-vivo results.

## 5. Conclusion

Within the study's limitations, light-cure RMGIC exhibited the highest debonding resistance among the tested materials, while Hybrid GIC showed the lowest. These findings indicate that the type of glass ionomer cement influences adhesion to saliva-contaminated dentin, with light-cure RMGIC demonstrating superior bonding performance compared to Type-IX and Hybrid GICs.

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