JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

# COMPARATIVE EVALUATION OF FRACTURE STRENGTH OF ALL-CERAMIC ZIRCONIA-BASED CROWN CEMENTED WITH GLASS IONOMER CEMENT AND RESIN MODIFIED GLASS IONOMER CEMENT FOR POSTERIOR SEMI-PERMANENT RESTORATION OF SECOND DECIDUOUS MOLAR- AN *IN VITRO* STUDY

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*Abstract*

**Introduction:**
Zirconia crowns are increasingly preferred for restoring primary molars due to their strength and esthetics. The longevity of such restorations depends not only on crown material but also on the luting cement. This in-vitro study aimed to compare the fracture strength of zirconia-based crowns cemented with Glass Ionomer Cement (GIC) and Resin-Modified Glass Ionomer Cement (RMGIC) for semi-permanent restoration of second deciduous molars.

**Methodology:**
Sixty-four mandibular second deciduous molar typodont teeth were selected and randomly divided into two groups (n=32). Standardized tooth preparation included 1.5–2 mm occlusal reduction, 0.5–1 mm axial reduction, 4°–8° taper, and a 0.5 mm chamfer margin. Group I crowns were cemented with GIC (Fuji I), while Group II crowns were bonded with RMGIC (Ionoseal, Voco). Following thermocycling, fracture strength testing was performed using a Universal Testing Machine by applying vertical compressive load at 1 mm/min until fracture occurred. Data were analyzed using an unpaired t-test with significance set at $p<0.05$.

**Results:**
Group I (GIC) exhibited a mean fracture strength of 1158.3 ± 88.0 N, whereas Group II (RMGIC) showed significantly higher strength at 1625.0 ± 58.5 N. The difference between the groups was highly significant ($p=0.001$).

**Conclusion:**
Zirconia crowns cemented with RMGIC demonstrated significantly greater fracture resistance compared to

GIC. Within the limitations of this study, RMGIC appears to be the preferred luting cement for enhancing the durability and longevity of zirconia crowns in posterior semi-permanent restorations of deciduous molars.

**Keywords:** Zirconia crowns, fracture strength, deciduous molars.

**Introduction-**

Primary (deciduous) teeth play a vital role in chewing, speech, appearance, and guiding the proper eruption of permanent teeth. [1] Their early loss can lead to malocclusion, speech and nutritional problems, while untreated caries may cause pain, infection, and affect growth. Thus, preserving primary teeth through good oral hygiene, timely restorations, and prosthetic care when needed is essential for a child's overall health.[2] The main cause of premature tooth loss in children is dental caries, particularly early childhood caries (ECC), linked to bacterial infection, high sugar intake, and poor oral hygiene. If untreated, it can progress to pulp involvement, pain, infection, and eventual tooth loss. Trauma from falls, sports, or accidents is another common factor, often leading to luxation, avulsion, or fractures that necessitate extraction when teeth cannot be restored. [3]

The second deciduous molars play a vital role in a child's oral development, emerging during early childhood and remaining functional until the mixed dentition phase. [4] Semi-permanent restorations serve as intermediate solutions that restore function and aesthetics while delaying definitive treatment, particularly for pediatric patients, those at high caries risk, or individuals awaiting final prosthetic placement. Compared to temporary fillings, they provide greater strength and durability, though they are not meant for long-term use. [5] Resin-modified glass ionomer cement (RMGIC) is commonly used for semi-permanent restorations in posterior primary teeth, including second molars, as the incorporation of resin components such as HEMA enhances the properties of conventional glass ionomer cement (GIC) by improving strength, wear resistance, and moisture tolerance while maintaining fluoride release and chemical adhesion. [6] Its sustained fluoride release prevents recurrent caries and supports remineralization, making it ideal for children with high caries risk. [7, 8] Fracture strength, defined as a material's ability to resist masticatory forces before failure, is crucial for semi-permanent restorations in posterior teeth such as second deciduous molars, ensuring durability under occlusal load until exfoliation or definitive treatment. [8] Materials with higher fracture strength, such as RMGIC, perform better against wear and chipping than conventional GIC [7], while all-ceramic zirconia crowns are increasingly preferred for posterior primary teeth due to their superior strength, durability, aesthetics, and biocompatibility. Compared to stainless steel crowns and composite resins, zirconia restorations offer enhanced fracture resistance, wear resistance, and esthetic outcomes. [9]

Restoration of second deciduous molars is crucial for preserving arch integrity, maintaining proper chewing function, and ensuring space for permanent successors. Zirconia crowns, though superior in strength and esthetics compared to stainless steel crowns, rely heavily on the type of cement used for clinical success. Glass ionomer cement (GIC) and resin-modified glass ionomer cement (RMGIC) are preferred choices because of their fluoride release and adhesion, yet their comparative fracture resistance in zirconia restorations is not well established. [10] This study aims to assess and compare the fracture strength of zirconia crowns luted with GIC and RMGIC, providing evidence-based guidance for pediatric restorative care.

## Materials and Methods

### Study Design

This in-vitro experimental study was conducted in the Department of Pedodontics and Preventive Dentistry, Rajasthan Dental College and Hospital, Jaipur, over a period of three months. Ethical approval for the study protocol was obtained from the Institutional Research and Ethical Committee.

### Sample Selection and Grouping

A total of **64 posterior primary mandibular molar typodont teeth** were selected according to predefined inclusion and exclusion criteria. Teeth were randomly allocated into two groups (n = 32 each):

- **Group I**: Zirconia crowns cemented with **Glass Ionomer Cement (Fuji I, GC)**
- **Group II**: Zirconia crowns bonded with **Resin-Modified Glass Ionomer Cement (Ionoseal, Voco)**

### Inclusion Criteria

- Posterior primary mandibular molar typodont teeth with intact structure, free from cracks or fractures
- Standardized preparation with appropriate occlusal and axial reduction
- All-ceramic zirconia crowns specifically designed for primary molars with an accurate fit

### Exclusion Criteria

- Teeth or crowns fractured/damaged during preparation or cementation
- Improper or uneven preparation affecting cement adhesion
- Misfit crowns after cementation

### Tooth Preparation

Standardized preparation was carried out with a high-speed air-rotor handpiece and fine diamond burs under water coolant. The preparation included:

- Occlusal reduction: 1.5–2 mm
- Axial reduction: 0.5–1 mm
- Taper: 4°–8°
- Chamfer margin: 0.5 mm circumferential reduction

Prepared teeth were inspected for uniformity and accuracy.

**Cementation Procedure**

Zirconia crowns were luted using either GIC (Group I) or RMGIC (Group II). Crowns were seated under finger pressure, and excess cement was carefully removed. Samples were stored in distilled water at 37°C for 48 hours.

**Thermocycling**

All specimens were subjected to thermocycling to simulate intraoral temperature fluctuations:

- 10,000 cycles between 5°C and 55°C
- Dwell time: 30 seconds at each temperature

**Fracture Strength Testing**

Fracture strength was evaluated using a Universal Testing Machine (UTM). A vertical compressive load was applied to the marginal ridge at a crosshead speed of 1 mm/min until fracture or dislodgement occurred. The maximum fracture load was recorded in Newtons (N).

**Failure Mode Analysis**

Fractured samples were examined under a stereomicroscope and categorized as:

- **Adhesive failure** – separation at tooth-cement or crown-cement interface
- **Cohesive failure** – fracture within the cement
- **Mixed failure** – combination of adhesive and cohesive modes

**Statistical Analysis**

Data were compiled in Microsoft Excel and analyzed using **SPSS version 30.0 (IBM, Chicago, USA)**. Descriptive statistics (mean and standard deviation) were calculated. Between-group comparison of fracture strength was performed using the **unpaired t-test**. A p-value<0.05 was considered statistically significant, with a 95% confidence interval.

**Result-**

The current study examined the fracture strengths of a zirconia-based crown bonded with a self-adhesive resin cement and a zirconia-based crown cemented with glass ionomer cement.

**Table 1- Comparison of mean fracture strength of Zirconia-based crown cemented with glass ionomer cement and bonded with a self-adhesive resin cement (n=64)**

| Groups | n | Fracture strength (N) | p-value |
|---|---|---|---|
| | | Mean± SD | |
| Group I (Zirconia-based crown cemented with glass ionomer cement) | 32 | 1158.3±88.0 | |

| | | | |
|---|---|---|---|
| **Group II (Zirconia-based crown bonded with a self-adhesive resin cement)** | **32** | **1625.0±58.5** | **0.001* (HS)** |

*Statistically highly significant

The results of this study indicate a statistically significant difference in the fracture strength of zirconia-based crowns based on the type of cement used. The p-value of **0.001** suggests a highly significant difference between the two groups. These findings suggest that self-adhesive resin cement provides superior bonding and reinforcement compared to glass ionomer cement, potentially enhancing the overall durability and clinical longevity of zirconia-based crowns.(Table 1)

**Table 2-Comparative Fracture Strength of Zirconia-Based Crowns Cemented with Different Luting Agents**

| **Groups** | **Mean difference** | **95% Confidence Interval of the Difference** | | **t-value** | **p-value** |
|---|---|---|---|---|---|
| | | **Lower** | **Upper** | | |
| Group I (Zirconia-based crown cemented with glass ionomer cement) | **466.75** | **1070.3** | **1246.3** | **-24.981** | **0.001* (HS)** |
| Group II (Zirconia-based crown bonded with a self-adhesive resin cement) | | **1566.5** | **1683.5** | | |

*Statistically highly significant

Table 2 presents the comparative fracture strength of zirconia-based crowns cemented with two different luting agents: glass ionomer cement (Group I) and self-adhesive resin cement (Group II). The mean difference between the two groups was 466.75 N, indicating significantly higher fracture strength in Group II.

The t-value of -24.981 suggests a strong statistical difference between the two groups. The p-value of 0.001 indicates a highly significant difference (HS), confirming that the choice of luting agent significantly affects the fracture strength of zirconia-based crowns. The findings suggest that self-adhesive resin cement provides superior bonding strength, leading to higher fracture resistance of zirconia crowns compared to glass ionomer cement.

**Table 3- Mode of Failure of Zirconia-Based Crowns Cemented with Different Luting Agents**

| **Mode of failure** | **Group I (Zirconia-based crown cemented with glass ionomer cement)** | **Group II (Zirconia-based crown bonded with a self-adhesive resin cement)** |
|---|---|---|
| **Adhesive Failure** | **26(81.25%)** | **12(37.5%)** |
| **Cohesive Failure** | **0(0.0%)** | **0(0.0%)** |

| | | |
|---|---|---|
| **Mixed Failure** | **6(18.75%)** | **20(62.5%)** |

The mode of failure analysis revealed distinct differences between the two groups. Similar to Group I, no cohesive failures were observed in Group II.

These findings suggest that self-adhesive resin cement provides stronger adhesion to zirconia-based crowns, reducing the likelihood of complete debonding (adhesive failure) and promoting a more integrated failure pattern (mixed failure), which may enhance clinical longevity and durability.

**Discussion-**

The present study demonstrated that zirconia crowns cemented with self-adhesive resin cement exhibited significantly higher fracture strength compared to those luted with glass ionomer cement ($p = 0.001$). This finding highlights the critical role of luting agents in determining the mechanical performance of zirconia restorations.

Previous research supports these results. **Sharma et al**. reported that resin cements significantly improved the fracture strength of zirconia crowns compared to glass ionomer cements, primarily due to superior adhesive and mechanical properties. [11] Similarly, **Indergård et al**. confirmed that resin-based cementation enhanced fracture load compared with non-adhesive techniques, emphasizing cement choice as a determining factor in clinical success. [12] In contrast, **Nakamura et al.** found no significant difference among various cements, including resin, GIC, and zinc phosphate, suggesting that factors such as crown thickness and preparation design may overshadow cement effects. [13]

The present findings align with studies by **Al-Akhali et al**., who demonstrated that resin cements improve fracture resistance by establishing both micromechanical and chemical bonds with the zirconia surface. [14] Furthermore, the incorporation of MDP-containing primers with resin cements has been shown to significantly enhance bond durability and fracture resistance, owing to stable chemical interaction between 10-MDP monomers and zirconia. [15] This chemical affinity is particularly important, as zirconia lacks a silica phase for conventional silane bonding.

Despite these advantages, the intrinsic strength of zirconia itself may limit the impact of cement type in certain scenarios, as suggested by **Nakamura et al**. [13] Variations in outcomes across studies may be attributed to methodological differences such as thermocycling protocols, crown design, and cementation techniques. Nevertheless, a consistent trend favoring resin-based cements is observed when proper surface conditioning and primer application are employed. [16]

The mode of failure analysis provides key insights into the bond integrity between luting agents and zirconia crowns, influencing their clinical performance and longevity. In this study, Group I (GIC) showed predominantly adhesive failures (81.25%), indicating weak bonding at the cement–tooth or cement–crown interface, which can lead to debonding and restoration loss. In contrast, Group II (self-adhesive resin cement, SARC) exhibited fewer adhesive failures (37.5%) and more mixed failures (62.5%), reflecting stronger mechanical interlocking and chemical adhesion due to the presence of MDP monomers and dual-curing properties. The absence of cohesive failures in both groups suggests adequate internal cement strength, with failure mainly occurring at the interface.

Fracture strength analysis showed that GIC-cemented crowns had lower strength (1158.3 N ± 88.0) and mainly adhesive failures, while SARC-cemented crowns demonstrated higher fracture strength (1625.0 N ± 58.5) with more mixed failures, indicating a stronger, more integrated bond. A strong negative correlation between fracture strength and adhesive failure in the GIC group, and a positive correlation between fracture strength and mixed failure in the SARC group, further supports this.

These findings align with previous studies by **Al-Akhali et al**.[17], **Kern et al**.[18], and **Sailer et al**.[19], which reported superior bonding and fracture resistance of resin-based cements over GICs. Although some discrepancies, such as those reported by **Al-Dahoudi et al**.[20], exist, they likely stem from methodological variations. Overall, self-adhesive resin cements demonstrate superior bonding efficacy and fracture resistance for zirconia crowns, emphasizing their clinical advantage over conventional glass ionomer cements.

Clinically, the use of self-adhesive resin cement offers enhanced retention, improved distribution of occlusal forces, and reduced risk of catastrophic failure, making it a preferable option for zirconia crowns in posterior primary molars. Given the growing application of zirconia restorations in pediatric dentistry, adopting resin-based luting strategies can contribute to more predictable long-term outcomes.

*Conclusion*

Self-adhesive resin cement significantly improves the fracture strength and bonding integrity of zirconia crowns compared to glass ionomer cement. These findings support its clinical use for enhanced durability and predictable performance in pediatric zirconia restorations.

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