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Comparative Evaluation of the Compressive Strength of Self-Cure and Light-Cure Glass Ionomer-Based Cements in a Simulated Oral Environment: An In Vitro Study

Sayed Zain Mashhoor[1], Shashank Gaur[2], Neha Singh[3], Akanksha Mishra[4], Tanvi Ila Ram[5]

[1]Postgraduate Student, Department of Pediatric & Preventive Dentistry, Bhabha College of Dental Sciences, Bhopal, MP, India

[2]Professor & Head, Department of Pediatric & Preventive Dentistry, Bhabha College of Dental Sciences, Bhopal, MP, India

[3]Professor, Department of Pediatric & Preventive Dentistry, Bhabha College of Dental Sciences, Bhopal, MP, India (Corresponding Author)

[4]Associate Professor, Department of Pediatric & Preventive Dentistry, Bhabha College of Dental Sciences, Bhopal, MP, India

[5]Postgraduate Student, Department of Pediatric & Preventive Dentistry, Bhabha College of Dental Sciences, Bhopal, MP, India

Corresponding Author: Dr. Neha Singh

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KEYWORDS

Glass Ionomer Cement; Compressive Strength; Self-Cure; Light-Cure; Restorative Materials

ABSTRACT:

Background: Glass Ionomer Cements (GICs) are commonly used in pediatric restorative dentistry due to chemical adhesion, fluoride release and biocompatibility. Mechanical strength - particularly compressive strength is important when selecting GICs for stress-bearing restorations.

Aim: To compare the compressive strength of two self-cure and two light-cure glass ionomer-based restorative materials after storage in artificial saliva.

Materials and Methods: An in vitro study was performed on 20 cylindrical specimens prepared using prefabricated Teflon molds (4 mm diameter × 6 mm height). Subgroups (n = 5 each): A1 — ChemFil Rock (self-cure), A2 — GC Fuji IX GP Fast (self-cure), B1 — GC Fuji II LC (light-cure), B2 — Ketac N100 (light-cure). Specimens were prepared per manufacturer instructions, stored incommercially available artificial saliva at 37°C for 2 weeks, and tested for compressive strength using an Instron universal testing machine (cross-head speed 1.0 mm/min). Compressive strength was calculated in MPa. Data are presented as mean ± SD.One-way ANOVA (subgroup comparison) followed by Tukey's HSD post-hoc test, and an independent t-test (Group A vs Group B) were performed (SPSS v22). Significance set at $p \leq 0.05$.

Results: Means (MPa): A1 81.4 ± 2.30; A2 77.0 ± 1.58; B1 90.0 ± 1.58; B2 83.0 ± 1.58. One-way ANOVA: $F(3,16) = 45.56$, $p = 4.63\times10^{-8}$. Independent t-test (self- vs light-cure): $t(18) = -4.65$, $p = 0.0002$.

Conclusion: Light-cure glass ionomer-based cements showed significantly higher compressive strength than self-cure GICs under the conditions tested. GC Fuji II LC demonstrated the highest compressive strength among tested materials.

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Introduction

Glass ionomer cements (GICs) have been widely used in pediatric dentistry since their introduction in the 1970s, owing to their chemical adhesion to enamel and dentin, fluoride release, and biocompatibility.[1,2] These properties make them particularly valuable in children, where preservation of tooth structure and prevention of secondary caries are critical clinical goals.[3,4] Despite these advantages, the long-term success of restorations depends heavily on mechanical properties. Among these, compressive strength is especially important as it determines the ability of a restoration to withstand occlusal forces in stress-bearing areas. Studies have shown that insufficient compressive strength can contribute to restoration failure, marginal breakdown, and reduced clinical longevity.[5,6] To improve performance, newer formulations have been developed. Conventional self-cure GICs set via an acid–base reaction, whereas resin-modified and light-cure GICs incorporate resin components and polymerization chemistry to enhance handling and strength.[7,8] Evidence regarding their mechanical superiority, however, is mixed: some studies report higher compressive and flexural strength in resin-modified/light-cure GICs, while others found no significant difference compared with conventional materials.[9,10] Furthermore, laboratory conditions may influence results. Storage in artificial saliva provides a more clinically relevant model than water alone, as saliva affects water uptake, ion exchange, and fluoride recharge of GICs.[11] Given the importance of selecting durable restorative materials for pediatric patients, especially in load-bearing areas, further research is warranted. This study therefore aimed to evaluate and compare the compressive strength of two self-cure and two light-cure GICs after immersion in artificial saliva for two weeks. The null hypothesis was that there would be no significant difference in compressive strength between self-cure and light-cure GICs.

Materials and Methods

Study Design and Area: An in vitro experimental study was conducted in the Department of Pediatric and Preventive Dentistry, Bhabha College of Dental Science, Bhopal, Madhya Pradesh.

Materials: Four glass ionomer based restorative materials were tested: ChemFil Rock (self-cure), GC Fuji IX GP Fast (self-cure), GC Fuji II LC (light-cure), Ketac N100 (light-cure).

Sample Size and Grouping

A total of **20 cylindrical specimens** were prepared (4 mm diameter × 6 mm height), divided into four subgroups (n = 5 per subgroup):

- **Group A1:**ChemFil Rock (self-cure)
- **Group A2:** GC Fuji IX GP Fast (self-cure)
- **Group B1:** GC Fuji II LC (light-cure)
- **Group B2:**Ketac N100 (light-cure)

For group-wise comparison, specimens were also analyzed in two main categories:

- **Group A (Self-cure):** A1 + A2 (n = 10)
- **Group B (Light-cure):** B1 + B2 (n = 10)

Sample size and specimen preparation: Twenty cylindrical specimens (4.0 mm diameter × 6.0 mm height) were prepared using Teflon molds (n = 5 per subgroup). Petroleum jelly was applied inside the mold. Materials were mixed and handled according to manufacturers' instructions by a single operator. Light-cure specimens were polymerized using an LED curing unit. Any defective specimens were discarded and replaced; no replacements were needed.

Storage: Specimens were stored in commercially available artificial saliva at 37 °C for 2 weeks to simulate oral conditions.

Testing procedure: After storage, specimen diameters were measured with a digital caliper and the mean diameter used for calculations. Specimens were placed vertically between the platens of a universal testing machine (Shimadzu, Kyoto, Japan) and loaded at a cross-head speed of 1.0 mm/min until fracture. Maximum load (P, N) was recorded. Compressive strength (C, MPa) was calculated as $C = 4P / (\pi d^2)$, where d is the mean diameter (mm) and $\pi = 3.1416$.

Statistical analysis: Data were analyzed using SPSS v22.0 (IBM Corp.). Descriptive statistics (mean ± sample SD) were calculated. Normality (Shapiro–Wilk) and homogeneity of variance (Levene) were tested. One-way ANOVA was used to detect differences among subgroups, followed by post-hoc pairwise comparisons

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with **Tukey's Honestly Significant Difference (HSD) test**. An independent *t*-test compared combined self-cure (Group A) vs combined light-cure (Group B). Significance was set at $p \leq 0.05$.

Results

The mean compressive strength values (MPa) and standard deviations (SD) for each subgroup is presented in Table 1. Among the tested materials, GC Fuji II LC (B1) exhibited the highest mean compressive strength (90.0 ± 1.58 MPa), while GC Fuji IX GP Fast (A2) showed the lowest (77.0 ± 1.58 MPa).

Table 1. Mean compressive strength (MPa) of four tested materials (n = 5 per subgroup)

Group	Material	Mean (MPa)	SD (MPa)	n
A1	ChemFil Rock (Self-cure)	81.4	2.30	5
A2	GC Fuji IX GP Fast (Self-cure)	77.0	1.58	5
B1	GC Fuji II LC (Light-cure)	90.0	1.58	5
B2	Ketac N100 (Light-cure)	83.0	1.58	5

When grouped by curing mechanism, the combined self-cure group (Group A: A1 + A2) demonstrated a mean compressive strength of 79.2 ± 2.97 MPa, while the combined light-cure group (Group B: B1 + B2) had a mean compressive strength of 86.5 ± 3.98 MPa.

Table 2. Group-wise comparison of compressive strength between self-cure and light-cure GICs

Group	Mean (MPa)	SD (MPa)	n
Group A (Self-cure)	79.2	2.97	10
Group B (Light-cure)	86.5	3.98	10

Statistical Analysis

One-way ANOVA revealed significant differences among the four subgroups ($F(3,16) = 45.56$; $p = 4.63 \times 10^{-8}$). Post-hoc pairwise comparisons using Tukey HSD showed that GC Fuji II LC (B1) had significantly greater compressive strength than ChemFil Rock (A1), GC Fuji IX GP Fast (A2) and Ketac N100 (B2) (mean differences = 8.6, 13.0 and 7.0 MPa respectively; all *p*-adj ≤ 0.0001). GC Fuji IX GP Fast (A2) was significantly weaker than B1 and B2 (mean differences = 13.0 and 6.0 MPa respectively; *p*-adj ≤ 0.0004), while ChemFil Rock (A1) and Ketac N100 (B2) did not differ significantly (mean difference = 1.6 MPa; *p*-adj = 0.509).

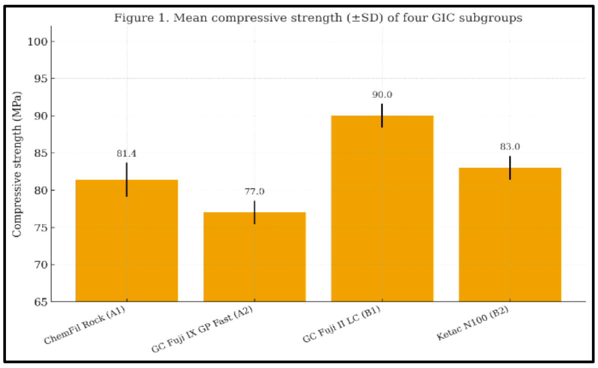

Figure 1: Bar chart showing mean compressive strength (±SD) of all four subgroups (A1, A2, B1, B2). GC Fuji II LC (B1) demonstrated the highest strength, while GC Fuji IX GP Fast (A2) showed the lowest

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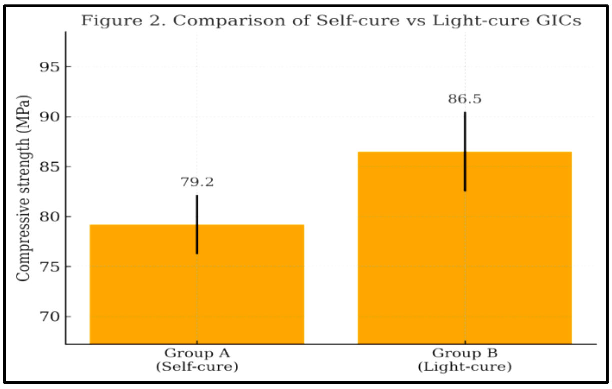

Figure 2: Bar chart comparing mean compressive strength (±SD) of Group A (Self-cure) vs Group B (Light-cure). Light-cure GICs demonstrated significantly higher values than self-cure GICs

Discussion

In this controlled in vitro study, light-cure GICs exhibited higher compressive strength than self-cure GICs after two weeks' storage in artificial saliva. GC Fuji II LC demonstrated the highest mean compressive strength, which could be attributed to its resin-modified formulation and the additional polymerization afforded by light curing. Higher compressive strength suggests better suitability for stress-bearing restorations in pediatric patients; however, other clinical factors such as adhesion, fluoride release, wear resistance and ease of handling must also guide material choice. Our findings align with several recent studies reporting higher compressive strength for resin-modified (light-cure) GICs relative to conventional self-cure GICs. Ganeshapooban et al. (2024) found that the resin-modified glass ionomer ("Riva Light Cure") exhibited significantly greater compressive strength than a conventional GIC ("Riva Self-Cure") at both 24 hours and 28 days, concluding that the cross-linked polymer network in RMGICs provides higher strength than the acid–base gel of conventional GICs.[12] Malhotra et al. (2022) reported compressive strength ranking as: GC Gold Label hybrid (a highly filled ionomer) > RMGIC > conventional GIC, again placing the resin-modified group above the conventional cement.[13] Chandru et al. (2023) likewise observed the greatest compressive strength in a light-cure GIC (Ketac N100) and the least in a conventional GIC (Fuji IX), concluding that light-cured GICs outperformed self-cured ones.[14] These findings are consistent with our data showing Fuji II LC (light-cure) and Ketac N100 (light-cure) exceeding the strengths of ChemFil Rock and Fuji IX (self-cure), with Fuji II LC yielding the highest value. In contrast, other studies have found conventional GICs to be stronger under certain conditions. Adnan et al. (2022) tested Fuji IX and ChemFil Rock (conventional GICs) against two RMGICs (Fuji-Plus and Fuji II LC) and reported that at both 1 day and 28 days, the conventional cements had higher compressive strength (mean ≈179–221 MPa) than the resin-modified materials (mean ≈109–173 MPa).[15] In their work, ChemFil Rock (high-viscosity GIC) reached the highest values and Fuji-Plus the lowest. Notably, at 28 days Fuji IX (conventional) reached ~198 MPa versus ~173 MPa for Fuji II LC (RMGIC), reversing the trend seen at earlier time points. These discrepancies between studies likely reflect differences in material formulations, powder/liquid ratios, specimen aging times, and testing conditions (e.g. storage medium and temperature). The superior strength of RMGICs in many studies can be attributed to their dual-cure chemistry. Unlike conventional GICs, RMGICs contain polymerizable resin monomers (e.g. HEMA, UDMA) in addition to the standard acid–base components. Upon light activation, these monomers co-polymerize to form a cross-linked polymer network intertwined with the ionomer matrix. This network imparts greater stiffness and fracture resistance early on. Ganeshapooban et al. noted that the cross-linked polymer matrices of RMGICs yield higher compressive strength than the gel-like matrix of conventional GICs.[12] Scanning electron microscopy studies support distinct microstructures: Lagarde et al. (2018) demonstrated that varying the light-curing delay alters the polymer phase in Fuji II LC, and that the competition between acid–base and resin polymerization produces different microstructures and mechanical properties.[16] In RMGICs, the polymerization may entrain the acid–base reaction or even limit it, whereas conventional GIC relies solely on the slower ionic set. Thus, RMGICs typically gain strength more rapidly, which may benefit short-term performance, while some conventional GICs (especially high-viscosity types) can continue to strengthen over weeks. Clinically, these strength differences have implications for pediatric restorative dentistry. Glass ionomers are favored in children for their fluoride release, chemical adhesion to tooth

structure, and tolerance of moisture, all of which help prevent secondary caries in high-risk patients. The American Academy of Pediatric Dentistry notes that recent developments have largely overcome earlier drawbacks of GICs (poor wear and fracture resistance), making them increasingly important in pediatric care.[17] Adequate compressive strength is essential for posterior restorations in primary molars, which, although subjected to lower forces than permanent teeth, still experience significant occlusal load. Our results suggest that resin-modified GICs (like Fuji II LC and Ketac N100) could better withstand these forces than self-cure GICs. Importantly, the ideal material choice also depends on handling and safety: RMGICs offer faster set times and immediate polishability, which can be beneficial in uncooperative children, but they require light-curing and contain resin monomers (potentially less biocompatible than conventional GIC). In practice, the clinician must balance these factors. As Chandru et al. emphasize, pediatric dentists often prioritize ease of use and sufficient mechanical strength when selecting a GIC.[14] Our findings support using light-cure GICs in stress-bearing situations when mechanical load is a concern, while acknowledging that all GICs provide fluoride release and chemical bond to enamel and dentin. This study has limitations inherent to in vitro research. The sample size was modest and limited to four materials, so statistical power and generalizability are constrained. Specimens were tested under static compressive loading after 2 weeks in artificial saliva, which does not fully mimic the complex oral environment with thermal cycling, pH variation, and dynamic masticatory forces. Additionally, the specific powder/liquid ratios, mixing methods, and sample geometry can influence measured strengths. Future work could include fatigue or wear testing, longer aging periods, and larger sample sizes. Despite these limitations, the consistent trend across multiple materials - that resin-modified GICs showed higher compressive strength than the self-cured GICs tested - is clear and aligns with recent literature.[12,13,14]

Conclusion

Within the limits of this in vitro study, light-cured (resin-modified) glass ionomers demonstrated significantly higher compressive strength than self-cured (conventional) cements. GC Fuji II LC yielded the highest strength and GC Fuji IX the lowest. Clinically, the enhanced strength of RMGICs suggests they may be preferable for load-bearing restorations in children, provided proper curing and handling are ensured. Conventional GICs remain valuable for their bioactivity and ease of use. Overall, this study highlights the mechanical advantage of resin modification in GICs and supports their use when higher compressive strength is desired, while recognizing that in vivo performance will depend on additional factors not assessed here.

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