



## EVALUATION OF COMPRESSIVE STRENGTH, FLUORIDE RELEASE, AND RECHARGE ABILITY BETWEEN GIOMER AND GLASS IONOMER RESTORATIVE MATERIALS

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### Abstract

**Background:** Over the past three decades, dentistry has made significant advances in restorative materials, aiming to achieve optimal durability, aesthetics, and fluoride-releasing properties to reduce caries risk. The purpose of the study is to compare the compressive strength, fluoride release, and recharge capacity of Giomer and traditional glass ionomer restorative materials.

**Aim of the study:** The aim of the study was to compare the compressive strength, fluoride release, and recharge capacity of Giomer and traditional glass ionomer restorative materials.

**Methods:** This in vitro experimental study at the Department of Conservative Dentistry & Endodontics, Bangabandhu Sheikh Mujib Medical University (BSMMU), in collaboration with the Analytical Research Division and the Pilot Plant & Process Development Centre, Bangladesh Council of Scientific and Industrial Research (BCSIR) Laboratories, Dhaka, Bangladesh (2007–2008), assessed fluoride release, recharge, and compressive strength of Composite, Compomer, Giomer, and Glass-Ionomer discs, with measurements via ion-selective electrode/ion chromatography and universal testing machine, analyzed using ANOVA and Bonferroni tests ( $p < 0.05$ ).

**Results:** Giomer showed the highest compressive strength (271.36 MPa), followed by composite (238.60 MPa) and compomer (203.44 MPa) with no significant difference ( $p > 0.05$ ). Fluoride release was highest in glass ionomer both before (Day 1: 8.54 ppm; Day 3: 1.99 ppm; Day 6: 1.04 ppm) and after recharge (Day 7: 1.37 ppm; Day 10: 0.95 ppm; Day 13: 0.90 ppm), while giomer showed the lowest values; all intergroup differences were significant ( $p < 0.001$ ).

**Conclusion:** Giomer showed the highest compressive strength, while glass ionomer exhibited superior fluoride release and recharge capacity.

**Key words:** Compressive Strength, Fluoride Release, Recharge Ability.

### Introduction

Over the past three decades, the field of dentistry has witnessed significant scientific progress, particularly in the development and refinement of restorative materials and clinical techniques. A

wide range of restorative materials has been introduced with the aim of achieving optimal intraoral performance in terms of durability, aesthetics, and relief of symptoms [1]. The incorporation of fluoride into restorative materials has garnered considerable attention among dental researchers and clinicians because of their potential to act as reservoirs that gradually release fluoride, which is particularly beneficial for patients at high risk of dental caries [2]. Fluoride's role in preventing dental caries has been recognized since the early 1930s. It enhances the resistance of teeth to caries through multiple protective mechanisms, encompassing both biological and physicochemical effects [3].

Glass ionomer cements (GICs) were first developed in the United Kingdom in 1969 and became commercially available in the 1970s. These restorations offer several advantages, including the ability to replicate natural tooth color, biocompatibility, the capacity to release and absorb fluoride within enamel and dentin, a coefficient of thermal expansion similar to that of natural tooth structure, and the ability to chemically bond to both enamel and dentin [4]. To address the limitations of conventional glass-ionomer cements, hybrid materials combining the features of GICs and composite resins were introduced. These hybrid restorative materials primarily include resin-modified glass-ionomer cements (RMGICs), compomers (polyacid-modified composites), and giomers [5]. Compomers are aesthetic materials that integrate the benefits of traditional composites and glass-ionomer cements [6]. Their clinical popularity arises from several advantages, including ease of handling, no requirement for mixing, good polishability, resistance to dehydration, radiopacity, and the ability to release fluoride [7].

Giomers represent a novel category of hybrid aesthetic restorative materials. They incorporate components of both glass-ionomer cements and resins but differ from compomers and are classified separately as pre-reacted glass-ionomer (PRG) composites [8]. Giomers demonstrate excellent aesthetics, color matching, smooth surface finish, reduced microleakage, and clinical stability, making them suitable for restoring non-carious cervical lesions, such as abrasion or erosion, as well as class V cavities in both primary and permanent teeth [9]. Despite the advantages of GICs, their mechanical limitations—including brittleness, low toughness, and insufficient strength—restrict their use in stress-bearing posterior regions. Composites, in contrast, exhibit favorable mechanical properties but generally release only minimal amounts of fluoride.

Resin-modified glass-ionomer cements (RMGICs) retain an acid-base reaction as part of their curing mechanism, whereas compomers contain glass-ionomer fillers embedded within a composite resin matrix, providing both aesthetic and mechanical benefits along with fluoride release to susceptible tooth surfaces in high-carries-risk individuals [10]. Giomers, such as Beautifil II, utilize surface prereacted glass (S-PRG) ionomer filler particles, offering fluoride release comparable to GICs while maintaining the superior mechanical properties of composite resins [11]. Fluoride is widely acknowledged as an anticariogenic agent. Restorative materials capable of releasing fluoride can help reduce recurrent caries at restoration margins [12-16], which is the leading cause of restoration failure [17,18]. The anticariogenic effects of fluoride involve multiple mechanisms, including the formation of fluorapatite with lower solubility than natural apatite, enhanced remineralization, disruption of ionic bonding during pellicle and plaque formation, and inhibition of microbial growth and metabolism [19,20]. The fluoride release from restorative materials typically decreases sharply after the initial few days but can be partially restored or recharged by exposure to topical fluoride agents or fluoride-containing dentifrices. The capacity for fluoride recharge, however, varies significantly among different types of restorative materials [21]. Among these materials, glass-ionomer cements are noted for their remarkable fluoride recharging ability [22]. Conventional GICs and resin-modified GICs remain widely used fluoride-releasing restoratives, yet their inherent brittleness, low toughness, and limited strength prevent their application in load-bearing posterior areas, whereas composites provide superior mechanical performance but relatively low fluoride release.

Although various restorative materials have been developed with enhanced mechanical properties and fluoride release, few studies have simultaneously compared the compressive strength and fluoride recharge ability of giomers and traditional glass ionomer cements. Most previous research has focused on either mechanical performance or fluoride release individually, leading to limited guidance for

clinical decision-making in high-carries-risk patients. This study aims to address this gap by systematically evaluating both properties in giomer and glass ionomer restoratives. The purpose of the study is to compare the compressive strength, fluoride release, and recharge capacity of Giomer and traditional glass ionomer restorative materials.

### Objective

- To compare the compressive strength, fluoride release, and recharge capacity of Giomer and traditional glass ionomer restorative materials.

### Methodology & Materials

This experimental in vitro study was conducted at the Department of Conservative Dentistry & Endodontics, Bangabandhu Sheikh Mujib Medical University (BSMMU), in collaboration with the Analytical Research Division and the Pilot Plant & Process Development Centre, BCSIR Laboratories, Dhaka, Bangladesh, between January 2007 and December 2008. A total of seven disc specimens of each restorative material were prepared for evaluation of fluoride release and recharge, and another seven specimens for measurement of compressive strength. The restorative materials included Composite (Quixfil, Caulk/Dentsply, Germany), Compomer (Dyract Extra, Dentsply DeTrey, Germany), Giomer (Beautifil II, Shofu Inc., Japan), and Glass-Ionomer (Fuji IX, GC America).

**Specimen Preparation:** For fluoride release and recharge, cylindrical Teflon molds (10 mm × 4 mm) were filled with the respective material, pressed between glass slides, and light-cured for 40 s on each surface; self-curing glass-ionomer specimens were allowed to set naturally. After 24 h storage at 37°C, specimens were ground with 800-grit silicone carbide paper, and their dimensions measured to calculate surface area. Compressive strength specimens were prepared using Teflon molds (4 mm × 6 mm) and cured or set similarly.

**Fluoride Release and Recharge:** Specimens were immersed individually in 5 mL of distilled/deionized water at 37°C, with daily solution replacement for six days. Fluoride concentration was measured using an ion-selective electrode (ISE) and ion chromatography (IC), and results expressed as µg/cm<sup>2</sup> (ppm). Following Day 6, specimens were recharged in 5 mL of 250 ppm aqueous sodium fluoride for 1 h, rinsed, and returned to fresh water, with fluoride release subsequently measured on Days 7, 10, and 13.

**Compressive Strength and Statistical Analysis:** Compressive strength was assessed using a universal testing machine (Testometric AX) at a cross-head speed of 1.0 mm/min. Compressive strength (CS) was calculated as  $CS = P/\pi r^2$ , where P is the fracture load and r is the radius of the specimen. Data were analyzed using SPSS v11.5, presented as mean ± SD, and compared using ANOVA with Bonferroni post-hoc tests; p < 0.05 was considered statistically significant.



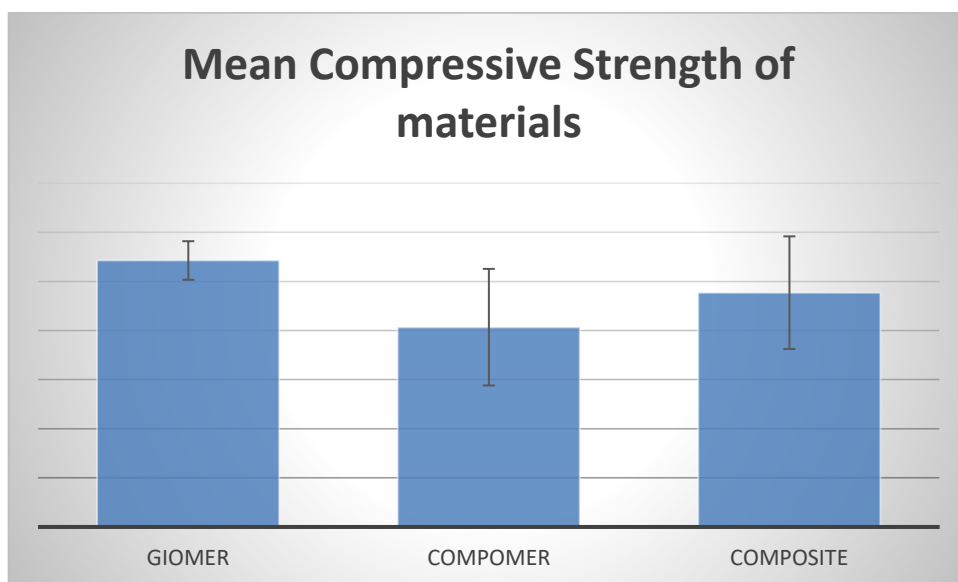
**Figure 1: Compression of Giomer Specimen Using Glass Slab in Teflon Mold**



**Figure 2: Cured Glass-Ionomer Specimens Prepared for Fluoride Release Assessment**



**Figure 3: Fluoride Ion Eluates in Chromatography Vials Prior to IC Quantification Results**



**Figure 4: Comparison of Compressive Strength among Giomer, Compomer, and Composite Restorative Materials**

Figure 4 illustrates the mean compressive strength values of giomer, compomer, and composite. The giomer group showed the highest mean compressive strength, followed by composite, while the lowest value was recorded for compomer. However, the differences among the three materials were not statistically significant ( $p > 0.05$ ).

**Table 1: Fluoride Release (ppm) by Giomer, Compomer, and Glass Ionomer before Recharge (Day 1, 3, 6)**

| Material                  | Day 1<br>Range   | Day 1<br>Mean $\pm$ SD | Day 3<br>Range  | Day 3<br>Mean $\pm$ SD | Day 6<br>Range  | Day 6<br>Mean $\pm$ SD |
|---------------------------|------------------|------------------------|-----------------|------------------------|-----------------|------------------------|
| Giomer                    | 1.080–<br>1.413  | 1.288 $\pm$<br>0.126   | 0.266–<br>0.383 | 0.315 $\pm$<br>0.052   | 0.164–<br>0.373 | 0.246 $\pm$<br>0.064   |
| Compomer                  | 1.997–<br>2.439  | 2.111 $\pm$<br>0.162   | 0.466–<br>0.577 | 0.517 $\pm$<br>0.046   | 0.419–<br>0.522 | 0.473 $\pm$<br>0.037   |
| Glass Ionomer             | 6.460–<br>10.562 | 8.538 $\pm$<br>1.282   | 1.698–<br>2.480 | 1.988 $\pm$<br>0.246   | 0.950–<br>1.174 | 1.040 $\pm$<br>0.073   |
| Comparison                |                  |                        |                 |                        |                 |                        |
|                           |                  |                        |                 | Day 1                  | Day 3           | Day 6                  |
| Giomer vs Compomer        |                  |                        |                 | >0.10                  | >0.05           | <0.001                 |
| Giomer vs Glass Ionomer   |                  |                        |                 | <0.001                 | <0.001          | <0.001                 |
| Compomer vs Glass Ionomer |                  |                        |                 | <0.001                 | <0.001          | <0.001                 |

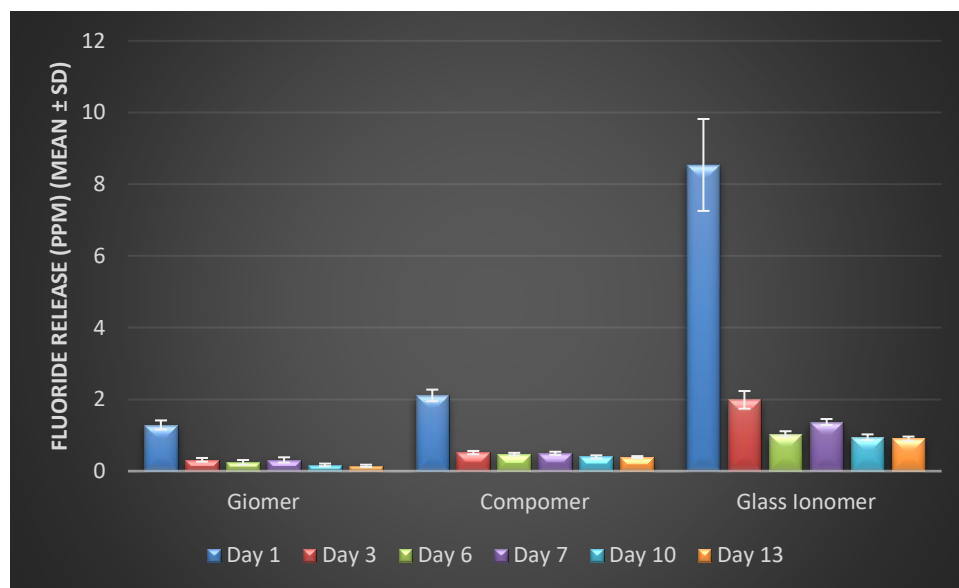
Table 1 shows the mean fluoride release of giomer, compomer, and glass ionomer at Day 1, Day 3, and Day 6 before fluoride recharge. Across all time points, glass ionomer exhibited the highest mean fluoride release, while giomer consistently showed the lowest. On Day 1, there was no significant difference between giomer and compomer ( $P > 0.10$ ), whereas the differences between giomer and glass ionomer, and compomer and glass ionomer were statistically significant ( $P < 0.001$ ). On Day 3, giomer and compomer again showed no significant difference ( $P > 0.05$ ), while differences between giomer and glass ionomer and between compomer and glass ionomer remained significant ( $P < 0.001$ ). By Day 6, all pairwise comparisons (giomer vs compomer, giomer vs glass ionomer, compomer vs glass ionomer) were statistically significant ( $P < 0.001$ ).

**Table 2: Fluoride Release (ppm) by Giomer, Compomer, and Glass Ionomer after Recharge (Day 7, 10, 13)**

| Material                  | Day 7<br>Range  | Day 7<br>Mean $\pm$ SD | Day 10<br>Range | Day 10<br>Mean $\pm$ SD | Day 13<br>Range | Day 13<br>Mean $\pm$ SD |
|---------------------------|-----------------|------------------------|-----------------|-------------------------|-----------------|-------------------------|
| Giomer                    | 0.190–<br>0.418 | 0.313 $\pm$<br>0.073   | 0.119–<br>0.227 | 0.173 $\pm$<br>0.037    | 0.089–<br>0.193 | 0.147 $\pm$<br>0.032    |
| Compomer                  | 0.434–<br>0.581 | 0.497 $\pm$<br>0.044   | 0.329–<br>0.461 | 0.399 $\pm$<br>0.042    | 0.353–<br>0.426 | 0.393 $\pm$<br>0.026    |
| Glass Ionomer             | 1.279–<br>1.508 | 1.371 $\pm$<br>0.082   | 0.803–<br>1.504 | 0.946 $\pm$<br>0.079    | 0.826–<br>0.988 | 0.904 $\pm$<br>0.060    |
| Comparison                |                 |                        |                 |                         |                 |                         |
|                           |                 |                        |                 | Day 7                   | Day 10          | Day 13                  |
| Giomer vs Compomer        |                 |                        |                 | <0.001                  | <0.001          | <0.001                  |
| Giomer vs Glass Ionomer   |                 |                        |                 | <0.001                  | <0.001          | <0.001                  |
| Compomer vs Glass Ionomer |                 |                        |                 | <0.001                  | <0.001          | <0.001                  |

Table 2 presents the mean fluoride release of giomer, compomer, and glass ionomer at Day 7, Day 10, and Day 13 following fluoride recharge. At all time points after recharge, glass ionomer demonstrated the highest mean fluoride release, while giomer consistently showed the lowest. The differences in fluoride release between all pairs of materials (giomer vs compomer, giomer vs glass

ionomer, and compomer vs glass ionomer) were statistically significant at all three time points ( $P < 0.001$ ).



**Figure 5: Fluoride release by giomer, compomer and glass ionomer (before and after recharge)**

## Discussion

Restorative materials play a critical role in maintaining tooth structure, preventing secondary caries, and ensuring long-term oral health, particularly in patients at high risk for dental decay. The findings of this study emphasize the differences in mechanical and anticariogenic properties among giomers, compomers, and glass ionomer cements. While giomers demonstrated higher compressive strength, glass ionomers exhibited superior fluoride release and recharge capacity. These results underscore the importance of selecting restorative materials based on both structural performance and preventive potential to optimize clinical outcomes in restorative dentistry.

In the present study, giomer demonstrated the highest mean compressive strength (271.356 MPa) compared to compomer (203.444 MPa) and composite (238.598 MPa), although the differences were not statistically significant ( $p > 0.05$ ). This finding aligns with Vijayan et al.[23], who reported that among giomer, composite, resin-modified glass ionomer cement (RMGIC), and compomer, giomer exhibited the highest hardness, a surrogate measure of mechanical strength, supporting its superior structural integrity. Similarly, Walia et al.[9] found that giomer had the maximum compressive strength among the tested restorative materials (Giomer > Ceram-x > Zirconomer > Ketac Molar), further corroborating the enhanced mechanical properties of giomer. These results suggest that the combination of a resin matrix with surface pre-reacted glass filler technology in giomer contributes to its improved compressive strength relative to compomer and composite materials.

Regarding fluoride release before recharge, glass ionomer consistently showed the highest mean fluoride release at all measured time points, followed by compomer and giomer. On Day 1, glass ionomer exhibited an initial burst release of 8.538 ppm, markedly higher than compomer (2.111 ppm) and giomer (1.288 ppm). Although fluoride release from all materials declined over time, the trend persisted through Day 6. These observations are consistent with Mousavinasab et al.[24], who reported that conventional glass ionomer cement (GIC) released the highest cumulative fluoride over the first week, followed by giomer and compomer in descending order. Similarly, Itota et al.[25] found that GICs had superior fluoride release and recharge ability relative to giomer and compomer. The superior fluoride release of GIC can be attributed to its ongoing acid–base reaction and continuous ion exchange, whereas giomer and compomer, which rely on a pre-reacted glass filler phase within a resin matrix, exhibit comparatively lower fluoride diffusion.

Following fluoride recharge, glass ionomer again demonstrated the highest mean fluoride release at Day 7 (1.371 ppm), Day 10 (0.946 ppm), and Day 13 (0.904 ppm), while giomer showed the lowest release and compomer remained intermediate. The differences between all pairs of materials were statistically significant ( $P < 0.001$ ), establishing a clear hierarchy in fluoride recharge capacity. These findings are supported by Bansal et al.[26], who reported that conventional GIC not only released the highest fluoride initially but also demonstrated superior recharge ability compared to giomer and compomer. The enhanced fluoride recharge of glass ionomer is likely due to its ionic network and acid–base reaction, which facilitate fluoride uptake and sustained release, whereas the resin matrices and pre-reacted glass fillers in giomer and compomer limit their ability to reabsorb and release fluoride efficiently.

### Limitations of the study

This study had some limitations:

- **In vitro setting:** The study was conducted under laboratory conditions, which may not fully replicate the complex oral environment, including saliva, pH fluctuations, and masticatory forces, potentially affecting fluoride release and compressive strength in vivo.
- **Small sample size:** Only seven specimens per material were tested for each parameter, which may limit the statistical power and generalizability of the results.
- **Short-term evaluation:** Fluoride release and recharge were monitored for a maximum of 13 days, which may not reflect long-term performance and durability of the restorative materials.

### Conclusion

Giomer exhibited the highest compressive strength, though not significantly different from compomer and composite. Glass ionomer demonstrated the greatest fluoride release and recharge capacity at all time points, followed by compomer and giomer, with statistically significant differences among materials. These results indicate that giomer is preferable for mechanical strength, while glass ionomer offers superior fluoride release and remineralization potential.

**Acknowledgment:** I would like to express my sincere gratitude for the invaluable support and cooperation provided by the staff, participants, and my co-authors/colleagues who contributed to this study.

**Conflicts of interest:** There are no conflicts of interest.

**Ethical approval:** The study was approved by the Institutional Ethics Committee.

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