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EFFICACY OF GIOMER VERSUS GLASS IONOMER IN COMPRESSIVE STRENGTH AND FLUORIDE DYNAMICS

Dr. Sheikh Muhammad Abdul Quader[1*], Dr. Abdullah Al Mahmud[2], Mst. Laila Akter Banu[3]

[1*]Associate Professor, Department Of Conservative Dentistry & Endodontics, Update Dental College & Hospital, Dhaka, Bangladesh
[2]Assistant Professor, Department Of Conservative Dentistry & Endodontics, Sapporo Dental College & Hospital, Dhaka, Bangladesh
[3]Assistant Professor, Department Of Conservative Dentistry & Endodontics, Dhaka Dental College & Hospital, Dhaka, Bangladesh

***Corresponding Author:** Dr. Sheikh Muhammad Abdul Quader
*Associate Professor, Department Of Conservative Dentistry & Endodontics, Update Dental College & Hospital, Dhaka, Bangladesh

Abstract

Background: Restorative materials that combine mechanical durability with fluoride release are essential for caries prevention. Glass ionomer cements (GICs) are known for their fluoride dynamics but have limited strength, whereas giomers incorporate pre-reacted glass fillers into a resin matrix, promising improved mechanical and fluoride characteristics. This study compared the compressive strength and fluoride release–recharge behavior of giomer and glass ionomer restorative materials.

Methods: An experimental in vitro design was used in this study. Fourteen disc specimens of giomer and glass ionomer were prepared for fluoride release testing, and another fourteen specimens of giomer and composite were evaluated for compressive strength. Fluoride release was measured for six days using an ion-selective electrode and ion chromatography, followed by fluoride recharge with 250 ppm sodium fluoride solution and reassessment on days 7 and 13. The compressive strength was measured using a universal testing machine. Data were analyzed using ANOVA and Bonferroni tests at a significance level of $p < 0.05$.

Results: Giomer exhibited a higher mean compressive strength (271.36 ± 19.65 MPa) than the composite (238.60 ± 57.34 MPa), although the difference was not significant ($p = 0.178$). Glass ionomer released significantly more fluoride than giomer, before and after recharge ($p < 0.001$).

Conclusion: Giomer exhibited superior compressive strength, whereas glass ionomer demonstrated greater fluoride release and recharge ability. Material selection should consider clinical demands, with giomers favored for strength and glass ionomers for fluoride-based caries prevention.

Keywords: Giomer, glass ionomer cement, compressive strength, fluoride release, fluoride recharge, restorative material.

Introduction

Restorative dental materials have evolved significantly over the past few decades, emphasizing not only mechanical durability but also bioactivity and cariostatic potential. Among fluoride-releasing materials, glass ionomer cements (GICs) and giomers are among the most widely investigated due to their ability to inhibit secondary caries and sustain ion exchange at the tooth–restoration interface. GICs were introduced in the 1970s as water-based materials composed of polyalkenoic acid and fluoroaluminosilicate glass, which bond chemically to enamel and dentin while continuously releasing fluoride ions [1,2]. This property enhances remineralization and reduces recurrent caries risk. Despite these advantages, GICs possess notable drawbacks such as brittleness, low fracture resistance, and sensitivity to early moisture contamination, limiting their use in stress-bearing restorations [3,4].

To overcome these limitations, hybrid materials incorporating resin components were developed. Among them, giomers—resin-based composites containing surface pre-reacted glass (S-PRG) fillers—represent an innovative class that bridges the gap between GICs and resin composites [5]. In giomers, fluoridated glass particles undergo pre-reaction with polyacrylic acid, forming a glass-ionomer phase that is then embedded within a resin matrix. This structure allows the material to combine the fluoride release and recharge potential of GICs with the superior mechanical, aesthetic, and handling properties of composite resins [6,7]. Studies have demonstrated that giomers possess smooth surface finish, color stability, and high wear resistance, attributes that make them suitable for both anterior and posterior restorations [8].

While both materials release fluoride, the mechanisms differ. In GICs, fluoride release occurs primarily through diffusion and ionic exchange within a hydrogel matrix, resulting in a characteristic "burst effect" followed by a gradual sustained release [9]. Giomers, on the other hand, depend on diffusion through the resin matrix from S-PRG fillers, producing lower but more stable fluoride release profiles [10]. Furthermore, fluoride recharge—the ability to absorb fluoride from external sources and re-release it—is clinically relevant for long-term caries prevention. GICs have consistently shown superior recharge and re-release capabilities due to their porous structure and hydrophilic nature, while giomers exhibit moderate recharge efficiency [11,12].

The mechanical properties, particularly compressive strength, are equally critical for the longevity of restorative materials. High compressive strength is essential to resist masticatory stresses and prevent material fracture. Several studies have reported that giomers and resin-modified glass ionomers (RMGICs) exhibit greater mechanical performance than conventional GICs because of resin polymerization and improved filler dispersion [13,14]. However, the trade-off often lies in reduced fluoride release, prompting ongoing research to optimize the balance between mechanical strength and bioactivity [15].

Comparative studies have produced varying outcomes. Poornima et al. noted that giomers showed significantly higher compressive strength but lower fluoride release than GICs, whereas Rai et al. observed the opposite trend in fluoride dynamics [4,10]. Such inconsistencies underscore the need for standardized testing protocols to compare these materials comprehensively under controlled conditions.

Given these considerations, this study aimed to evaluate and compare the compressive strength and fluoride release and recharge behavior of giomer and glass ionomer restorative materials under identical laboratory conditions. By elucidating their performance differences, the study seeks to assist clinicians in making evidence-based decisions when selecting restorative materials that best balance strength and caries-preventive efficacy.

Materials & Methods

This experimental in-vitro study was conducted at the Department of Conservative Dentistry and Endodontics, Bangabandhu Sheikh Mujib Medical University, Dhaka, Bangladesh, in collaboration with the Analytical Research Division and the Pilot Plant & Process Development Centre of the Bangladesh Council of Scientific and Industrial Research (BCSIR), Dhaka. The study period extended from January 2007 to December 2008. A total of 28 disc-shaped specimens were prepared: 14 for assessing fluoride release and recharge (seven giomer, seven glass ionomer) and 14 for evaluating compressive strength (seven giomer, seven composite). Materials tested included Giomer (Beautifil II, Shofu Inc., Japan) and Glass Ionomer (Fuji IX, GC America).

Sample Preparation: For fluoride testing, disc specimens (10 mm diameter × 4 mm height) were moulded using Teflon cylinders and polymerized according to the manufacturer's instructions. Light-curable specimens were cured for 40 seconds on each surface using a visible light-curing unit (Selector, Taiwan), while self-curing specimens were allowed to set chemically. After polymerization, specimens were stored dry at 37°C for 24 hours and then polished using 800-grit silicon carbide paper to standardize surfaces.

For compressive strength testing, specimens (4 mm diameter × 6 mm height) were prepared similarly, ensuring consistent dimensions and surface finish before testing.

Study Procedure: Fluoride release was evaluated by immersing each specimen in 5 mL of deionized water at 37°C. The storage solution was replaced daily for six days, and fluoride concentration was measured using an Ion Selective Electrode (ISE) and Ion Chromatography (IC). After initial fluoride release assessment, samples were recharged with 250 ppm sodium fluoride solution for one hour on Day 6, rinsed, and placed in fresh deionized water for subsequent fluoride release evaluation on Days 7 and 13. The amount of fluoride released was expressed as $\mu g/cm^2$ (ppm).

Compressive strength was determined using a Universal Testing Machine (Testometric AX) at a crosshead speed of 1.0 mm/min until fracture. The compressive strength (MPa) was calculated using the equation:

$$CS = \frac{P}{\pi r^2}$$

where P represents the fracture load (N) and r the specimen radius (mm).

Statistical Analysis: Data were analyzed using SPSS (version 11.5). Descriptive statistics (mean ± SD) were computed for all parameters. Comparisons between materials were performed using ANOVA followed by Bonferroni multiple comparison tests to identify significant differences. The level of significance was set at $p < 0.05$.

Results

Table 1: Compressive strength of giomer and composite

Material	n	Compressive strength MPA		P-value
		Range	Mean ±SD	
Giomer	7	246.113-305.752	271.356 ±19.653	0.178
Composite	7	146.265-302.234	238.598 ±57.338	

Table 1 presents the compressive strength (MPa) of giomer and composite restorative materials. The mean compressive strength of giomer (271.36 ± 19.65 MPa) was higher than that of composite (238.60 ± 57.34 MPa). Although Giomer exhibited a higher mean value, the difference between the two materials was not statistically significant ($p = 0.178$).

Table 2: Fluoride release by giomer and glass ionomer before recharge

	Material	n	Fluoride release (ppm)		P-value
			Range	Mean±SD	
Day-1	Giomer	7	1.080-1.413	1.288±0.126	<0.001
	Glass ionomer	7	6.460-10.562	8.538±1.282	
	Giomer vs Glass ionomer				<0.001
Day-6	Giomer	7	0.164-0.373	0.246±0.064	<0.001
	Glass ionomer	7	0.950-1.174	1.040±0.073	
	Giomer vs Glass ionomer				<0.001

Table 2 shows the comparative fluoride release (ppm) of giomer and glass ionomer before fluoride recharge. On Day 1, the glass ionomer exhibited a markedly higher fluoride release (8.54 ± 1.28 ppm) than the giomer (1.29 ± 0.13 ppm). By Day 6, fluoride release decreased in both materials, but glass ionomer maintained a significantly higher release (1.04 ± 0.07 ppm) compared to giomer (0.25 ± 0.06 ppm). All comparisons showed statistically significant differences ($p < 0.001$).

Table 3: Fluoride release by giomer and glass ionomer after recharge

	Material	n	Fluoride release (ppm)		P-value
			Range	Mean±SD	
Day-7	Giomer	7	0.190-0.418	0.313±0.073	<0.001
	Glass ionomer	7	1.279-1.508	1.371±0.082	
	Giomer vs Glass ionomer				<0.001
Day-13	Giomer	7	0.089-0.193	0.147±0.032	<0.001
	Glass ionomer	7	0.826-0.988	0.904±0.060	
	Giomer vs Glass ionomer				<0.001

Table 3 demonstrates fluoride release after recharge with 250 ppm sodium fluoride. On Day 7, following recharge, glass ionomer continued to show higher fluoride release (1.37 ± 0.08 ppm) than giomer (0.31 ± 0.07 ppm). By Day 13, both materials showed a decline in fluoride release, though glass ionomer still released more fluoride (0.90 ± 0.06 ppm) than giomer (0.15 ± 0.03 ppm). All comparisons between materials and time intervals remained statistically significant ($p < 0.001$).

Discussion

This study compared the compressive strength and fluoride dynamics of giomer and glass ionomer restorative materials. The findings revealed that giomer exhibited higher mean compressive strength than composite, whereas glass ionomer showed significantly greater fluoride release and recharge capacity than giomer. These results align with the dual nature of these materials—giomer being a resin-based hybrid optimized for strength, and glass ionomer being hydrophilic and ionically reactive, favoring fluoride exchange.

The compressive strength results demonstrated no statistically significant difference between giomer and composite materials, although giomer recorded slightly higher mean values. This observation supports previous findings by Kang et al., who reported that giomers, owing to their surface pre-reacted glass (S-PRG) fillers and resin matrix, exhibit enhanced polymer crosslinking and improved load-bearing capacity [6]. Similarly, Ozer et al. observed that giomer restorations maintained stable strength over a three-year clinical period, reflecting their mechanical durability [14]. The current data reinforce that resin-based matrices contribute to greater fracture resistance compared to conventional glass-ionomer matrices, which are brittle and more susceptible to microcracking [13,16].

In contrast, glass ionomer cements (GICs) have consistently shown lower compressive strength due to their acid-base reaction matrix and water sensitivity during setting. Study by Poornima et al. found that the incorporation of resin components or metal-reinforced fillers can improve the strength of GICs, though not to the level of resin-based materials [4]. The brittle nature of glass-ionomer bonds, combined with microstructural porosity, explains their lower strength values observed here. However, as Singh and Gurgan et al. emphasize, the clinical suitability of GICs in non-stress-bearing areas remains valid due to their adhesion and fluoride benefits [3,17].

The fluoride release profile observed in this study demonstrated a significantly higher initial release from glass ionomer than from giomer, both before and after recharge. The findings concur with reports by Mousavinasab and Meyers and Dziuk et al., who attributed the superior fluoride emission in GICs to continuous ionic diffusion from their hydrogel matrix [18,19]. Glass-ionomer cements release fluoride through both rapid initial "burst release" and prolonged diffusion over time, mechanisms that contribute to their cariostatic effect [9].

Giomer, while capable of fluoride release, exhibited markedly lower values, confirming observations from Tarasingh et al. and Rai et al. [7,10]. This reduction stems from the encapsulation of pre-reacted glass fillers within a resin matrix, limiting ion diffusion. Nonetheless, the presence of S-PRG fillers enables giomer to recharge fluoride and sustain a moderate release pattern, albeit lower than glass ionomer. Quader et al. similarly found that giomers demonstrated measurable recharge potential after fluoride exposure, though not equivalent to GICs [20].

Fluoride recharge and re-release capacity are crucial for long-term anticariogenic performance. The present study confirmed that both materials could uptake fluoride after exposure to a 250-ppm sodium fluoride solution, but glass ionomer showed superior re-release over time. Comparable patterns were reported by Paul et al. and May and Donly, highlighting the strong affinity of GIC matrices for fluoride ions [11,12]. The chemically active polyacid network in GICs allows reversible fluoride exchange, unlike the diffusion-limited release from resin-modified systems. The differences in recharge efficiency suggest that giomers may function effectively under regular fluoride exposure (e.g., from toothpaste or varnishes), but sustained fluoride replenishment is more robust in GICs [21,22].

From a clinical standpoint, the balance between mechanical and fluoride characteristics determines the optimal restorative choice. Giomers, with their higher strength and aesthetics, are suitable for stress-bearing restorations, particularly in posterior teeth. Conversely, glass ionomers, though mechanically weaker, are preferable in non-load-bearing areas, root caries, or pediatric applications where fluoride release is paramount [23]. The present study supports these complementary roles, suggesting that material selection should depend on both structural demands and caries risk.

In summary, the findings of this study reinforce that giomer exhibits superior compressive strength, while glass ionomer remains the gold standard for fluoride dynamics. The study underscores the ongoing need to engineer restorative materials that achieve an optimal synergy of strength and fluoride bioactivity.

Limitations of the study

This in-vitro study was limited by its controlled laboratory environment, which may not replicate intraoral conditions such as pH fluctuations, saliva, and biofilm interactions affecting fluoride release. The small sample size and short observation period also restrict the generalizability of the findings.

Conclusion

The Giomer restorative material demonstrated superior compressive strength compared with glass ionomer, confirming its suitability for stress-bearing restoration. Conversely, glass ionomer exhibited markedly higher fluoride release and recharge capacity, emphasizing its cariostatic potential in low-load regions. These findings highlight the distinct advantages of both materials: giomer for mechanical durability and aesthetics, and glass ionomer for fluoride bioactivity. The results support the judicious clinical selection of restorative materials based on individual case requirements, balancing strength and preventive benefits to optimize long-term restorative outcomes.

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

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