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Research Article

A Comparative Evaluation of Compressive Strength of Type IX GIC, Kids-e-Restore and Posterior Restorative Composite Material in Primary Molar's - An *In Vitro* study

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Abstract

Context: Pediatric dental restorations require materials with biocompatibility, fluoride release, and mechanical strength to endure occlusal forces and caries risk. Compressive strength is a crucial factor influencing the clinical durability of restorations, especially in primary molars subjected to masticatory stress.

Aims: To assess and compare the compressive strength of Type IX Glass Ionomer Cement (GC Gold Label), flowable glass ionomer composite resin (Kids-e-Restore), and posterior restorative composite material (3M™ Filtek Bulk Fill) in primary molars.

Settings and Design: This *in vitro* study used extracted primary molars to simulate pediatric posterior restorations with standardized class II cavity preparations.

Materials and Methods: Thirty caries-free extracted primary molars were randomly divided into three groups (n = 15 each):

- Group I: Type IX GIC.
- Group II: 3M™ Filtek Bulk Fill composite.
- Group III: Flowable GIC (Kids-e-Restore).

Restorations followed manufacturer protocols. Specimens were stored in distilled water at 37°C and tested for compressive strength using a Universal Testing Machine at 0.5 mm/min.

Statistical Analysis Used: Data were analyzed using ANOVA and Mann-Whitney U test. Significance was set at $p < 0.05$.

Results: 3M™ Filtek Bulk Fill showed the highest mean compressive strength (10437.8 ± 951.9 kN), followed by Type IX GIC (9778.0 ± 1151.7 kN), and flowable GIC (6436.0 ± 1238.0 kN), with statistically significant differences (p = 0.000).

Conclusion: 3M™ Filtek Bulk Fill is best suited for stress-bearing posterior pediatric restorations. Type IX GIC offers a balance of strength and fluoride release for non-load areas, while flowable GIC is recommended for low-stress applications or as a base material.

Keywords: *Primary Molar; Compressive Strength; Bonding Efficiency; Stress Distribution*

Introduction

Pediatric dentistry emphasizes the oral restorative and health needs of children, necessitating materials that promote durability, biocompatibility, and long-term success. Selection of restorative materials is especially important since children are more caries susceptible, have smaller teeth with thinner dentin and enamel, and frequently have difficulty controlling moisture during treatment. Also, their elevated occlusal forces require restorations with sufficient compressive strength to resist mastication and parafunctional activities like bruxism. Type IX GIC is widely utilized because of its fluoride release characteristic, which facilitates remineralization and prevention of caries, and therefore, it is especially suitable for high-risk caries patients. While its reduced compressive strength restricts its application to stress-bearing zones, bulk-fill composites have better mechanical properties, providing better strength and durability but necessitating stringent control of moisture, something that may prove difficult in the pediatric patient. Flowable GIC is a compromise, presenting intermediate adaptability with moderate strength and fluoride release, which proves useful for small to moderate cavities. Knowledge of the compressive strength of such materials is important in pediatric dentistry to provide restorations that are durable, functionally effective, and able to withstand the developing dentition.

Glass Ionomer Cement (GIC) has been widely utilized in pediatric and geriatric dentistry due to its biocompatibility, fluoride release, and chemical adhesion to enamel and dentin. These properties make GIC suitable for minimally invasive restorations. However, limitations like moisture sensitivity during initial setting, lower fracture toughness, and reduced wear resistance, restricting their use in high-stress areas. To overcome these drawbacks, GIC Type IX was introduced, offering enhanced strength, wear resistance, and improved fluoride release. Despite these advantages, moisture sensitivity and low early-stage mechanical strength remain key concerns.

Bulk-fill composites have been developed as an alternative to conventional composites and GIC. These materials allow for placement in larger increments (up to 4 - 5 mm), reducing clinical chair time while maintaining adequate polymerization. Bulk-fill composites exhibit superior mechanical properties, including higher compressive strength and improved resistance to wear, making them a preferred choice for posterior restorations. However, polymerization shrinkage and the need for proper isolation remain challenges in their application.

Flowable GIC has been introduced as an improved version of traditional GIC, offering better adaptability to cavity walls and enhanced mechanical properties. It serves as a viable alternative for restorative procedures requiring fluoride release, with improved strength and durability compared to conventional GIC. However, its compressive strength still falls below that of bulk-fill composites, limiting its use in high-load-bearing regions.

Compressive strength is a crucial mechanical property of restorative dental materials, particularly for those used in posterior load-bearing areas. A restorative material with insufficient compressive strength is prone to failure, fractures, and ultimately, complications leading to periodontal issues or tooth loss. Among available materials, Glass Ionomer Cement (GIC), bulk-fill composites, and flowable GIC have emerged as significant restorative options due to their unique properties and clinical advantages.

With these hindrances in mind, restorative materials such as Type IX Glass Ionomer Cement (GIC), bulk-fill composites, and flowable GIC are important in pediatric restorations.

Aim of the Study

This study aims to evaluate and compare the compressive strength of Type IX GIC, bulk-fill composite, and flowable GIC to determine their suitability for use in pediatric dentistry and posterior restorations.

Subjects and Methods

This current *invitro* study included a total of 45 unrestored, extracted primary molar. Fractured, carious, restored, and dental anomaly teeth were excluded. During the experimental procedure, the specimens were kept in distilled water at 37°C to simulate physiological conditions. The samples were randomly allocated into 3 subgroups, (n = 15), groups were assigned to one control and two experimental group of restorative materials: Type IX (GC Gold Label), Posterior Restorative Composite Material (3M™ Filtek Bulk Fill), And Flowable glass ionomer composite resin (Kids-e-Restore). A standard Class II cavities were prepared on the chosen teeth with a cylindrical round-end bur of 1.2 mm diameter. The dimensions of the cavities were standardized with a buccolingual width of 3 mm, axial depth of 2 mm, and mesial and distal extensions extending to 1 mm apical to the cementoenamel junction (CEJ). For standardizing the test conditions, all teeth were mounted in cold-cure acrylic molds of size 1×1×1 cm^3.

For group I {Type IX (GC Gold Label)}: The powder and liquid was mixed according to the manufactures instruction.

For group II {Posterior restorative composite material (3M™ Filtek Bulk Fill)}: The dentine was etched with 37% phosphoric acid, thoroughly washed with water and gently dries. Bonding agent was applied in one coat with microbrush, was let stand for 10 seconds. After that, the material was placed on the surface and light cured for 15 seconds.

For group III {Flowable glass ionomer composite resin (Kids-e-Restore)}: The dentine surface was etched with 37% phosphoric acid, thoroughly washed with water and gently dried. After that the material was placed and light cured for 15 seconds.

Compressive strength assessment

For testing, each sample was placed with the flat ends up between the plates of the Universal Testing Machine (Instron). A compressive load, at a crosshead speed of 0.5 mm/min, was applied until the restorative pellet fractured as shown in figure 1.

Figure 1: *Compressive strength assessment in which each sample was placed with the flat ends up between the plates of the universal testing machine (Instron).*

Results

The result showed that mean compressive strength with standard deviation of Glass Ionomer Cement Type IX (GC Gold Label) was 9778.0 kN ± 1151.7. The 95% confidence interval for the mean ranged from 8347.9 to 11208.0. Posterior Restorative Composite Material (3M™ Filtek Bulk Fill) exhibited the highest mean compressive strength with a standard deviation of 10437.8 kN ± 951.9, and a 95% confidence interval between 9255.7 and 11619.8. Flowable Glass Ionomer Composite Resin (Kids-e-Restore) showed the lowest mean compressive strength with a standard deviation of 6436.0 kN ± 1238.0, and a 95% confidence interval ranging from 4898.8 to 7973.1.

Statistical analysis revealed a significant difference between the groups, with an F-value of 18.33 and a p-value of 0.000, indicating a statistically significant difference among the tested materials, further explained in the table 1.

Materials	Compressive strength (kN)		95% Confidence interval for mean		p-value
	Mean	SD	Lower Bound	Upper Bound	
Type IX (GC Gold Label)	9778.0	1151.7	8347.9	11208.0	0.000*
Posterior Restorative Composite Material (3M™ Filtek Bulk Fill)	10437.80	951.9	9255.7	11619.8	
Flowable glass ionomer composite resin (Kids-e-Restore)	6436.0	1238.0	4898.8	7973.1	

Table 1: *Comparison of mean compressive strength of flowable GIC, GIC type IX and Bulkfill restorative composite.*

Discussion

Type IX GIC is commonly applied in pediatric dentistry because it has an anti-cariogenic effect and is thus appropriate for high-caries-risk children. Its chemical bonding to tooth structure obviates the need for other bonding agents, which makes clinical application easier. Although it has a lower compressive strength than composite resins, Type IX GIC is usually used for restorations in low-stress locations and as a liner or base beneath composite restorations [1]. Its improved formulation provides better wear resistance, and thus it is an acceptable choice in minimally invasive pediatric restorative treatments. However, its mechanical properties, particularly compressive strength, are generally lower compared to composite resins. The result of this study showed that among three restorative materials, bulk-fill composites exhibit the highest compressive strength, followed by Type IX GIC, while flowable glass ionomer composite resins, such as Kids-e-Restore, have the lowest compressive strength despite their improved resin-modified formulation for enhanced durability. In contrast, Somani., *et al.* (2016) evaluated the shear bond strength of various GICs and concluded that while GICs offer strong adhesion to dentin, their compressive strength remains a limitation [2].

Mazumdar., *et al.* highlighted that although flowable GICs provide better marginal adaptation and fluoride release, they are not as resistant to occlusal stresses as bulk-fill composites [3]. Another study by Arora., *et al*. also identified that flowable GICs had poorer wear resistance and compressive strength when compared to traditional resin-based restoratives, restricting their applications to low-stress clinical procedures [4]. The present study endorses these conclusions and reconfirms that hybrid flow materials such as Kids-e-Restore are optimally used as liners, bases, or in class V and class III restorations where minimal compressive load is encountered.

Compressive strength is a critical property for restorative materials, especially in posterior restorations where occlusal forces are much greater. Bulk-fill composites have proven to be a breakthrough innovation in restorative dentistry because they can be placed in increments up to 4 mm, saving time and minimizing technique sensitivity. Filtek Bulk Fill, specifically, has a novel monomer matrix and filler loading optimized to provide its increased mechanical performance and reduced polymerization shrinkage stress [5]. Such properties provide better durability and resistance to fracture when subjected to masticatory forces, thus rendering it the most suitable for restoring primary molars with continuous functional loading [6]. Previous studies, such as those conducted by Pathak., *et al.* (2021) and Pradeep., *et al.* (2016), have demonstrated that bulk-fill composites exhibit higher compressive strength compared to conventional GICs. Similarly, research by Khuderi., *et al*. (2016) suggests that the inclusion of nano-hybrid fillers in bulk-fill composites significantly enhances their mechanical properties [7-11].

Flowable glass ionomer composite resins, including Kids-e-Restore, blend the advantages of traditional GIC with enhanced malleability and handleability. Their low viscosity provides better cavity wall adaptation, minimizing microleakage and maximizing marginal integrity [12]. Based on the failure results, it has been observed that materials such as Flowable Glass Ionomer Composite Resin exhibit continuous fluoride release, leading to enamel remineralization and caries prevention in children [13]. Nevertheless, their reduced compressive strength restricts their use in stress-bearing regions, but they are more appropriate for non-load-bearing restorations, liners, or temporary restorations [14].

The present study corroborates these findings, demonstrating that 3M™ Filtek Bulk Fill exhibited the highest compressive strength among the tested materials, followed by Type IX GIC, with Kids-e-Restore showing the lowest values. This suggests that while Type IX GIC may be suitable for low-stress-bearing areas and as an interim restorative material, bulk-fill composites may be the preferred choice for high-stress areas in primary molars.

Additionally, these materials' performance under conditions mimicking aging processes, like load cycling and thermocycling, should be evaluated in future research to determine their durability and ability to resist deterioration. The impact of tooth design preparation, adhesives used, and clinician skill during clinical operation must also be looked into further because these can critically affect the restoration's success generally in pediatric cases.

Conclusion

Pediatric dentistry is concerned with the delivery of full oral health care to children and thus demands materials that are mechanically durable yet biologically compatible. From the findings of this *in vitro* study, it is therefore possible to conclude that 3M™ Filtek Bulk Fill had the highest compressive strength and would be an appropriate material for posterior restorations in primary molars where masticatory forces are maximum. Type IX Glass Ionomer Cement exhibited superior compressive strength compared to traditional GIC, providing a suitable alternative for restorations that need fluoride release with enhanced mechanical properties. Kids-e-Restore flowable glass ionomer composite resin had the lowest compressive strength of the materials tested, suggesting that it would be better suited for low-load-bearing restorations or as a base material. Further research using larger sample sizes and clinical testing is suggested to confirm these results and evaluate long-term performance in children.

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