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Comparative Evaluation of Microleakage in Type II GIC, Type IX GIC, and Resin-Modified GIC in Primary Teeth: An In Vitro Study

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ABSTRACT

Aim: This study aimed to evaluate and compare the microleakage of Type II glass ionomer cement (GIC), Type IX GIC, and resin-modified glass ionomer cement (RMGIC) restorations in primary teeth.

Materials and Methods: Thirty over-retained, non-carious primary molars beyond their exfoliation period were collected and randomly divided into three groups (n = 10 each). Group A: Type II GIC; Group B: Type IX GIC; Group C: RMGIC. Standardized Class V cavities were prepared on the buccal surface of each tooth without mechanical retention and restored with the respective materials. All samples were subjected to thermocycling for 250 cycles at varying temperatures, followed by coating with nail varnish. The specimens were then immersed in 0.5% methylene blue dye for 24 hours. Teeth were sectioned buccolingually through the center of the restoration and evaluated under a stereomicroscope for dye penetration. The data obtained were analyzed using Kruskal–Wallis ANOVA and Mann–Whitney U test.

Results: The RMGIC group demonstrated comparatively higher microleakage than the other groups. However, no statistically significant difference was observed among the three groups ($P > 0.05$).

Conclusion: Within the limitations of this study, Type II GIC, Type IX GIC, and RMGIC showed comparable microleakage performance in primary teeth.

Introduction

The success of restorative procedures in pediatric dentistry depends largely on the ability of the restorative material to provide an adequate marginal seal.[1] Microleakage, defined as the passage of bacteria, fluids, molecules, or ions between the cavity wall and the restorative material, remains a major concern as it can lead to postoperative sensitivity, secondary caries, pulpal irritation, and eventual restoration failure.[2,3]

Primary teeth present unique challenges for restorative treatment due to their distinct anatomical and histological characteristics, including thinner enamel and dentin, larger pulp chambers, and differences in bonding behavior. These factors increase the susceptibility of restorations in primary

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teeth to marginal leakage, making the selection of an appropriate restorative material critical.[4,5]

Glass ionomer cements (GICs) are widely used in pediatric dentistry because of their chemical adhesion to tooth structure, fluoride release, biocompatibility, and ease of use. Type II GIC is commonly employed for restorative purposes, while Type IX GIC, a high-viscosity variant, offers improved strength and wear resistance. Resin-modified glass ionomer cements (RMGICs) were developed to overcome the limitations of conventional GICs by incorporating resin components, thereby enhancing mechanical properties and reducing moisture sensitivity. However, the presence of resin may influence polymerization shrinkage and, consequently, microleakage.[6]

Despite the widespread use of these materials, there is still inconsistency in the literature regarding their sealing ability, particularly in primary teeth. Therefore, an in vitro evaluation of microleakage among different types of glass ionomer cements is essential to guide clinical decision-making.

Hence, the present study was undertaken to evaluate and compare the microleakage of Type II GIC, Type IX GIC, and resin-modified glass ionomer cement in primary teeth.

Material and Method

Thirty over-retained, non-carious primary molars beyond their exfoliation period were collected, cleaned, and stored in distilled water until use. The teeth were randomly divided into three groups (n = 10 each) based on the restorative material used:

- Group A: Type II GIC – GC Fuji II (GC Corporation, Tokyo, Japan)
- Group B: Type IX GIC – GC Fuji IX GP Extra (GC Corporation, Tokyo, Japan)
- Group C: Resin-Modified GIC – GC Fuji II LC (GC Corporation, Tokyo, Japan)

A standardized Class V cavity was prepared on the buccal surface of each tooth without any mechanical retention using a straight diamond bur under air–water cooling. The cavity dimensions were standardized to 4 mm in length, 2 mm in width, and 2 mm in depth. The depth of each preparation was verified using a periodontal probe.

All cavities were restored according to the manufacturers' instructions. Following restoration, the samples were subjected to thermocycling for 250 cycles between different temperatures to simulate oral conditions.

The tooth surfaces were then coated with nail varnish, leaving a 1 mm window around the restoration margins. Subsequently, all specimens were immersed in 0.5% methylene blue dye for 24 hours. After dye immersion, the teeth were rinsed thoroughly and sectioned buccolingually through the center of the restorations using a diamond disc. The sections were examined under a stereomicroscope to evaluate dye penetration. Microleakage was scored according to the criteria described by Khera and Chan:[7,8]

- Score 0: No leakage
- Score 1: Dye penetration less than or up to one-half of the cavity depth
- Score 2: Dye penetration more than one-half of the cavity depth but not reaching the junction of axial and occlusal/gingival wall
- Score 3: Dye penetration up to the junction of axial and occlusal/gingival wall but not including the axial wall
- Score 4: Dye penetration including the axial wall

The obtained data were subjected to statistical analysis using the Kruskal–Wallis ANOVA test and Mann–Whitney U test, with the level of significance set at $P < 0.05$.

Result

The distribution of microleakage scores (Table 1) indicates that all three restorative materials exhibited some degree of dye penetration, with none of the groups demonstrating complete absence of microleakage in all samples. Group B (Type IX GIC) showed a greater number of samples with lower scores (0 and 1), suggesting relatively better marginal sealing ability. In contrast, Group C (RMGIC) exhibited a higher frequency of samples with scores 2 and 3, indicating comparatively greater microleakage.

The mean microleakage scores (Table 2) further support this observation, where Group B (Type IX GIC) demonstrated the lowest mean score, followed by Group A (Type II GIC), while Group C (RMGIC) showed the highest mean microleakage. This trend suggests that Type IX GIC may provide improved marginal adaptation compared to the other materials, whereas RMGIC may be associated with relatively higher leakage, possibly due to polymerization shrinkage.

However, pairwise comparisons between the groups (Table 3) revealed no statistically significant differences ($P > 0.05$) in microleakage scores. This indicates that, despite observable variations in mean values and score distribution, the differences were not statistically significant.

Overall, the findings suggest that all three materials—Type II GIC, Type IX GIC, and RMGIC—exhibited comparable performance in terms of microleakage under the conditions of this study, with Type IX GIC showing a trend toward better sealing ability and RMGIC showing relatively higher leakage.

Table 1: Distribution of Microleakage Scores in Different Groups

Score	Group A (Type II GIC)	Group B (Type IX GIC)	Group C (RMGIC)
0	2	3	1
1	3	4	2
2	3	2	3
3	1	1	3
4	1	0	1
Total	**10**	**10**	**10**

Table 2: Mean Microleakage Scores of Study Groups

Group	Material	Mean Score ± SD
Group A	Type II GIC	1.50 ± 1.08
Group B	Type IX GIC	1.10 ± 0.99
Group C	RMGIC	2.10 ± 1.10

Table 3: Pairwise Comparison (Mann–Whitney U Test)

Comparison	P-value
Group A vs Group B	> 0.05
Group A vs Group C	> 0.05
Group B vs Group C	> 0.05

Discussion

Achieving an effective marginal seal remains a critical factor in the longevity of restorative materials, particularly in primary teeth where anatomical and structural differences predispose restorations to microleakage. The present study evaluated and compared the microleakage of Type II GIC, Type IX GIC, and resin-modified glass ionomer cement (RMGIC) in standardized Class V cavities of primary teeth.

The findings of this study demonstrated that all three materials exhibited some degree of microleakage. This is consistent with previous literature, which suggests that no restorative material is completely free from marginal leakage due to factors such as polymerization shrinkage, thermal stresses, and differences in the coefficient of thermal expansion between the tooth and restorative material.[9-12]

Among the tested materials, Type IX GIC showed comparatively lower microleakage scores. This may be attributed to its high viscosity, improved mechanical properties, and enhanced adaptation to cavity walls. The improved particle size distribution and higher powder-liquid ratio in Type IX GIC contribute to better marginal integrity and reduced porosity, thereby minimizing dye penetration.

Type II GIC demonstrated moderate microleakage. Although conventional GICs chemically bond to tooth structure and release fluoride, they are sensitive to moisture contamination during the initial setting phase and may exhibit inferior mechanical properties compared to high-viscosity variants. These factors could contribute to marginal discrepancies and subsequent microleakage.

The RMGIC group exhibited comparatively higher microleakage scores. While RMGICs were developed to overcome the limitations of conventional GICs by incorporating resin components, the polymerization shrinkage associated with the resin phase may lead to gap formation at the tooth–restoration interface. Additionally, differences in the dual-setting mechanism (acid-base reaction and light-activated polymerization) may influence marginal adaptation, particularly in Class V restorations where configuration factor (C-factor) is high.

Thermocycling was employed in this study to simulate oral temperature variations, which can induce expansion and contraction stresses at the tooth-restoration interface. These stresses may exacerbate marginal gaps and contribute to microleakage. The use of methylene blue dye penetration is a widely accepted and sensitive method for evaluating microleakage due to its low molecular weight and ability to penetrate small gaps.[13,14]

Despite observable differences in microleakage among the groups, statistical analysis revealed no significant difference. This suggests that, under the conditions of this study, all three materials performed comparably in terms of marginal sealing ability. The lack of statistical significance may be attributed to the sample size or inherent variability in in vitro conditions.

From a clinical perspective, all three materials can be considered acceptable for use in primary teeth restorations. However, the relatively lower microleakage observed with Type IX GIC suggests that it may offer a slight advantage in achieving better marginal seal, especially in situations where moisture control is challenging. On the other hand, the ease of handling and improved mechanical properties of RMGIC still make it a viable option despite its slightly higher leakage tendency.

Limitations of the Study

This study was conducted under in vitro conditions, which may not fully replicate the complex oral environment. Factors such as masticatory forces, saliva, pH variations, and long-term aging were not simulated. Additionally, the sample size was limited, which may influence the statistical outcome.

Future Recommendations

Further in vivo studies with larger sample sizes and long-term clinical evaluation are recommended to validate these findings. The use of advanced techniques such as micro-CT analysis or scanning electron microscopy could provide more precise assessment of marginal adaptation and microleakage.

Conclusion

Within the limitations of this in vitro study, it can be concluded that all three restorative materials—Type II GIC, Type IX GIC, and resin-modified glass ionomer cement—exhibited some degree of microleakage in primary teeth. Type IX GIC demonstrated comparatively lower microleakage, while resin-modified GIC showed relatively higher values. However, the differences among the groups were not statistically significant. Therefore, all three materials can be considered clinically acceptable with comparable sealing ability for restorations in primary teeth.

References

Dhar V, Hsu KL, Coll JA, Ginsberg E, Ball BM, Chhibber S, Johnson M, Kim M, Modaresi N, Tinanoff N. Evidence-based Update of Pediatric Dental Restorative Procedures: Dental Materials. J Clin Pediatr Dent. 2015 Summer;39(4):303-10.

Snehi, Pathivada L, Garg N, Karthik KM, Bhyri P, Koyande A. Comparative Evaluation of Marginal Microleakage of Different Forms of Glass Ionomer Cements in Primary Molars: An In Vitro Study. Int J Clin Pediatr Dent. 2025 May;18(5):544-547.

Bollu IP, Hari A, Thumu J, et al. Comparative evaluation of microleakage between nano-ionomer, giomer and resin modified glass ionomer cement in class v cavities—CLSM study. J Clin Diagn Res. 2016;10(5):66–70.

Salman KM, Naik SB, Kumar NK, et al. Comparative evaluation of microleakage in class V cavities restored with giomer, resin–modified glass ionomer, zirconomer and nano–ionomer: an in vitro study. J Int Clin Dent Res Organ. 2019;11(1):20–25.

Omidi BR, Naeini FF, Dehghan H, et al. Microleakage of an enhanced resin-modified glass ionomer restorative material in primary molars. J Dent. 2018;15(4):205–213.

Diem VTK, Tyas MJ, Ngo HC, et al. The effect of a nano-filled resin coating on the 3-year clinical performance of a conventional high-viscosity glass-ionomer cement. Clin Oral Investig. 2014;18(3):753–759.

Khera SC, Chan KC. Microleakage and enamel finish. J Prosthet Dent. 1978 Apr;39(4):414-9. doi: 10.1016/s0022-3913(78)80159-0. PMID: 273692.

Shruthi AS, Nagaveni NB, Poornima P, Selvamani M, Madhushankari GS, Subba Reddy VV. Comparative evaluation of microleakage of conventional and modifications of glass ionomer cement in primary teeth: An in vitro study. J Indian Soc Pedod Prev Dent. 2015 Oct-Dec;33(4):279-84.

Gurgan S, Kutuk ZB, Ergin E, et al. Four-year randomize clinical trial to evaluate the clinical performance of a glass ionomer restorative system. Oper Dent. 2015;40(2):134–143

Somani R, Jaidka S, Jawa D, Mishra S. Comparative evaluation of microleakage in conventional glass ionomer cements and triclosan incorporated glass ionomer cements. Contemp Clin Dent. 2014 Jan;5(1):85-8.

Gupta SK, Gupta J, Saraswathi V, Ballal S, Acharya SR. Comparative evaluation of microleakage in Class V cavities using various glass ionomer cements: An in vitro study. J Interdiscip Dent. 2012;2:164–9.

Diwanji A, Dhar V, Arora R, Madhusudan A, Rathore AS. Comparative evaluation of microleakage of three restorative glass ionomer cements: An in vitro study. J Nat Sci Biol Med. 2014 Jul;5(2):373-7.

Pavuluri C, Nuvvula S, Kamatham RL, Nirmala S. Comparative Evaluation of Microleakage in Conventional and RMGIC Restorations following Conventional and Chemomechanical Caries Removal: An in vitro Study. Int J Clin Pediatr Dent. 2014 Sep-Dec;7(3):172-5.

Hubel S, Mejare I. Conventional versus resin-modified glass ionomer cement for class II restorations in primary molars: A-3-year clinical study. Int J Paed Dent. 2003;13(1):2–8.