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In-Vitro Evolution of Microleakage of Different Restorative Material

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Abstract

Aim: To evaluate the degree of microleakage in restorative materials, namely Glass Ionomer Cement (GIC), Resin-Modified Glass Ionomer Cement (RMGIC), and Ormocer, using an in-vitro approach.

Materials and Methods: Standardized Class I cavities were prepared on extracted human molars and divided into three groups (n=10) based on the restorative material used: GIC (Group 1), RMGIC (Group 2), and Ormocer (Group 3). The cavities were filled with respective materials following manufacturers' instructions. All specimens underwent thermocycling to simulate oral conditions. Subsequently, teeth were immersed in a dye solution for 24 hours, sectioned buccolingually, and examined under a stereomicroscope to evaluate dye penetration, indicating microleakage. The extent of microleakage was scored and statistically analyzed using appropriate tests.

Results: Analysis revealed varying degrees of microleakage among the different materials. GIC exhibited the highest microleakage, followed by RMGIC, with Ormocer showing the least. Statistical significance was found between the groups ($p<0.05$).

Conclusion: Within the limitations of the study, Ormocer demonstrated superior resistance to microleakage compared to GIC and RMGIC. These findings suggest that Ormocer may provide a better seal and durability, potentially leading to improved clinical outcomes. However, clinical trials are necessary to confirm these results under in-vivo conditions.

Keywords: Microleakage, GIC, RMGI, Ormocer

Introduction: The success of dental restorations is significantly influenced by their ability to form a tight seal with the tooth structure, thereby preventing microleakage. Microleakage, the passage of bacteria, fluids, molecules, or ions between the cavity wall and the restorative material, can lead to secondary caries, pulpal irritation, and restoration failure.**[1]**

Traditional Glass Ionomer Cement has been a staple in restorative dentistry due to its fluoride release, chemical adhesion to tooth structures, and biocompatibility. However, its susceptibility to microleakage and lower mechanical strength are noted limitations.**[2]**

Resin-Modified Glass Ionomer Cement was developed to address some of these shortcomings, incorporating resin components to improve physical properties and handling characteristics. While RMGIC offers enhanced strength and reduced microleakage compared to traditional GIC, it still falls short of the ideal.**[3]**

Ormocers represent a newer class of restorative materials. Combining organic and inorganic components, ormocers aim to offer superior physical properties, reduced polymerization shrinkage, and enhanced biocompatibility. Their potential to minimize microleakage, however, requires further investigation.

This study aims to provide a systematic in-vitro evaluation of microleakage among these three materials - GIC, RMGIC, and Ormocer - to better understand their performance and guide clinical decision-making. By comparing these materials under standardized conditions, this research seeks to elucidate which material offers the best seal against microleakage, potentially leading to improved longevity and success of dental restorations.

Material and Method:

Sample Selection: A total of thirty non-carious, non-fluorosed human permanent premolars with intact occlusal surfaces were selected for the study, all of which had been extracted for orthodontic reasons. The teeth were disinfected in accordance with OSHA regulations, and ethical clearance was obtained from the institutional ethics committee.

Sample Preparation: Class I cavities were created on the occlusal surfaces of the extracted teeth, each with dimensions of 0.8 mm in width and 1.5 mm in depth. This was achieved using a high-speed handpiece equipped with an air-water coolant and a no. 245 bur. A William’s graduated periodontal probe was employed to measure the cavities' depth and width, ensuring uniformity. To maintain consistency in the cavity preparation, all cavities were prepared by a single operator.

Restorative Procedure: The teeth were randomly divided into three experimental groups of ten teeth in each.

Group I (*n* =10): GIC, Fuji 2, GC Corporation, Tokyo, Japan

Group II (*n* = 10): RMGIC, Vitremer, 3M, USA

Group III (*n* = 10): Ormocer, Admira Flow, Voco, Cuxhaven, Germany

In each group the cavity was restored with its respective restorative material according to the manufacturer's instructions.

Thermocycling and Dye Penetration: The samples underwent 500 cycles of thermocycling to simulate the thermal stresses experienced in the oral environment. Each cycle consisted of immersion in water baths at temperatures fluctuating between 5°C and 55°C, with each immersion lasting 60 seconds and a dwell time of 15 seconds between immersions.

After thermocycling, all tooth samples were thoroughly dried, and two coats of nail polish were applied to the entire dental structure, leaving a 1 mm window around the outer margins of the cavities uncoated. This ensured that only the margins were exposed to potential dye penetration.

Following a 24-hour period at room temperature to allow the nail polish to set, the teeth were submerged in a 2% methylene blue dye solution for another 24 hours. The teeth were then cleaned with distilled water to remove any excess dye from the surface.

For the assessment of dye penetration, each sample was sectioned through the middle of the restoration, both in the buccolingual and occlusal-cervical directions. This was achieved using a micromotor straight handpiece fitted with a diamond disc.

The prepared sections were examined under a stereomicroscope at a magnification of 40x. This close examination allowed for the observation and recording of the extent of dye penetration around the margins of the restorations, providing an indication of the microleakage occurring at those sites.

Evolution of Microleakage: The subsequent scoring criteria were utilized to evaluate microleakage:

Score 0: No evidence of leakage.

Score 1: Leakage extends to less than or equal to half the depth of the cavity preparation.

Score 2: Leakage extends to more than half the depth of the cavity preparation but does not reach the convergence point of the axial, occlusal, or cervical walls.

Score 3: Dye penetration reaches the juncture of the occlusal or cervical wall without involving the axial wall.

Score 4: Dye penetration includes the axial wall.

Result: Table 1 presents a comparative analysis of the mean microleakage values associated with three distinct esthetic restorative materials. The ormocer group exhibited the lowest marginal microleakage (1.15 ± 0.03), followed by the resin-modified glass ionomer cement (RMGIC) group (1.61 ± 0.05), and the glass ionomer cement (GIC) group (1.95 ± 0.03).

The comprehensive comparisons of mean microleakage across the three restorative materials are illustrated in Table 2. Notably, the analysis revealed statistically significant differences between the GIC group and the ormocer group, as well as between the RMGIC group and the ormocer gro

Table 1: Descriptive statistical analysis of microleakage score comparisons across different restorative materials

Group	**Microleakage score**					**Mean score ± SD**
	0	1	2	3	4	
Group I GIC	2 (20%)	4 (50%)	2 (20%)	1 (10%)	1 (10%)	1.95 ± 0.03
Group II RMGIC	4 (40%)	3 (30%)	1 (10%)	2 (20%)	-	1.61 ± 0.05
Group III Ormocer	6 (60%)	3 (30%)	1 (10%)	-	-	1.15 ± 0.03

Table 2: Overall comparisons of mean microleakage of three different restorative materials

Group	Comparison with	Mean Difference	Significance
GIC	RMGIC	0.34	> 0.05
	Ormocer	0.80	< 0.05*
RMGIC	GIC	- 0.34	> 0.05
	Ormocer	0.46	< 0.05*
Ormocer	GIC	- 0 .80	< 0.05*
	RMGIC	- 0.46	< 0.05*

Discussion: The study aimed to evaluate microleakage in three restorative materials—Glass Ionomer Cement, Resin-Modified Glass Ionomer Cement, and Ormocer - by preparing standardized Class I cavities on extracted human molars and analyzing dye penetration post-thermocycling.Glass Ionomer Cement; despite its popularity due to chemical adhesion to tooth structure and fluoride release, GIC exhibited the highest microleakage. This can be attributed to its inherent properties like lower flexural strength and prolonged setting time which may compromise its sealing ability.**[5]** RMGIC showed improved results over GIC, likely due to the addition of resin components which enhance physical properties and reduce microleakage. However, it still did not perform as well as Ormocer.**[6]** Ormocer outperformed both GIC and RMGIC in microleakage resistance. This improvement could be credited to its unique organic-inorganic hybrid structure, providing better mechanical properties and marginal integrity.**[7,8]**

Microleakage can lead to secondary caries, pulpal irritation, and restoration failure. Hence, materials demonstrating lower microleakage, like Ormocer, could be beneficial in clinical practice, potentially enhancing the longevity and performance of restorations. Fluoride Release While GIC and RMGIC are known for their fluoride-releasing properties, their higher microleakage may counteract these benefits. Balancing fluoride release with sealing ability is crucial in selecting a restorative material.**[7,9,10]**

The Ormocer group exhibited the smallest degree of marginal microleakage, followed by the Resin Modified Glass Ionomer Cement group and the GIC group. These findings align with the research by Yazici AR et al.**[11]**, which investigated the microleakage of Class V cavities repaired with three different types of flowable resin restorative materials. They reported that flowable composite materials were less effective than Ormocer. The likely rationale for the observed reduction in microleakage within the ormocer group is attributable to its unique structure, which comprises a biocompatible polysiloxane network characterized by minimal shrinkage even before light curing. The formation of the inorganic network initiates through hydrolysis and continues via the polycondensation of Si(OR)3 groups. Beginning with silane, polysiloxanes with polymerizable groups are produced. The preformed structure and exceedingly high molecular weight of ormocers result in complete polymerization, thereby experiencing significantly less shrinkage compared to composites or compomers. The three-dimensional architecture and low modulus of elasticity of ormocers potentially contribute to their reduced polymerization shrinkage, which could explain the lower microleakage scores.**[8,12]**

Conclusion: Ormocer demonstrated superior resistance to microleakage, suggesting better marginal integrity and potential for improved clinical outcomes. However, in-vivo validation is essential to fully endorse its clinical superiority.

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