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RESEARCH ARTICLE
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COMPARATIVE EVALUATION OF MICROLEAKAGE IN CLASS II RESTORATIONS USING BULK-FILL AND CONVENTIONAL COMPOSITE RESINS

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ABSTRACT

Objective: To comparatively evaluate microleakage in Class II restorations restored using bulk-fill composite resin and conventional incremental composite resin.

Materials and Methods: An in-vitro experimental study was conducted on extracted human premolars. Standardized Class II cavities were prepared and restored using either a conventional incremental composite resin or a bulk-fill composite resin. Following restoration and thermocycling, microleakage was assessed using dye penetration and stereomicroscopic evaluation. Statistical analysis was performed to compare microleakage between the groups.

Results: Both restorative techniques showed microleakage at occlusal and gingival margins. Gingival margins demonstrated higher microleakage in both groups. However, no statistically significant difference was observed between bulk-fill and conventional composite resins. **Conclusion:** Bulk-fill composite resins demonstrated microleakage comparable to conventional composite resins in Class II restorations and may be considered a reliable alternative with reduced operative time.

Keywords: Restorative dentistry, Microleakage, Class II Restorations Using Bulk-Fill, Conventional Composite Resins

INTRODUCTION

Composite resin materials have revolutionized restorative dentistry by offering superior esthetics, conservative cavity preparation, and adhesive bonding to tooth structure. Their widespread use in posterior restorations has increased significantly; however, achieving long-term marginal integrity remains a major clinical challenge.[1] Among the various factors affecting the success of composite restorations, polymerization shrinkage and the resultant microleakage are considered primary causes of restoration failure.[2]

Microleakage is defined as the passage of bacteria, fluids, molecules, or ions between the cavity wall and restorative material, which is clinically undetectable.[3] This phenomenon can lead to postoperative sensitivity, marginal staining, recurrent caries, pulpal inflammation, and eventual restoration failure.[4] Class II restorations are particularly susceptible to microleakage due to the presence of gingival margins in dentin or cementum, where bonding is less predictable than enamel.[5] Traditionally, composite resins are placed using an incremental layering technique to minimize polymerization shrinkage stress and ensure adequate depth of cure.[6] Although effective, this approach is time-consuming and technique-sensitive, increasing the risk of void formation and contamination between layers. In response to these limitations, bulk-fill composite resins were introduced, allowing placement of thicker increments up to 4–5 mm.[7] Bulk-fill composites incorporate modifications in filler content, resin matrix composition, translucency, and photoinitiator systems to enhance light penetration and reduce polymerization stress. Despite these advantages, concerns remain regarding their marginal sealing ability, especially in deep Class II cavities.[8]

Therefore, the present study aimed to compare the microleakage of Class II restorations restored using bulk-fill composite resin and conventional incremental composite resin.

MATERIALS AND METHODS

This in-vitro experimental study was conducted on extracted human premolars free from caries, restorations, cracks, or structural defects. The teeth were cleaned and stored in distilled water until use. Standardized Class II cavities were prepared using a high-speed handpiece under water cooling, with uniform dimensions and gingival margins placed 1 mm below the cemento-enamel junction. All cavity preparations were performed by a single operator to ensure standardization.

The specimens were randomly divided into two groups. In Group I, cavities were restored using a conventional nanohybrid composite resin placed incrementally in 2-mm layers. In Group II, cavities were restored using a bulk-fill composite resin placed in a single increment according to the manufacturer's instructions. A universal adhesive system was applied in both groups following the recommended bonding protocol. Light curing was performed using an LED curing unit with standardized intensity and curing time.

Following restoration, specimens were stored in distilled water at 37°C for 24 hours and then subjected to thermocycling between 5°C and 55°C to simulate oral thermal stresses. For microleakage assessment, all tooth surfaces were coated with nail varnish except for a 1-mm window around the restoration margins. The specimens were immersed in a dye solution, sectioned longitudinally, and examined under a stereomicroscope. Dye penetration was evaluated at occlusal and gingival margins and scored using an ordinal scoring system. Statistical analysis was carried out to compare microleakage between the groups.

RESULTS

Microleakage was observed in both restorative groups at occlusal and gingival margins (Table 1). Gingival margins showed higher dye penetration scores compared to occlusal margins in both groups (Table 2). However, no statistically significant difference was observed between bulk-fill and conventional composite resin groups (Table 3).

Table 1: Mean Microleakage Scores at Occlusal Margins

Group	Mean Score	Standard Deviation
Conventional Composite	0.72	0.45
Bulk-Fill Composite	0.68	0.42

Table 2: Mean Microleakage Scores at Gingival Margins

Group	Mean Score	Standard Deviation
Conventional Composite	1.38	0.52
Bulk-Fill Composite	1.32	0.49

Table 3: Overall Comparison of Microleakage Scores

Margin Location	Conventional Composite	Bulk-Fill Composite	p-value
Occlusal	0.72 ± 0.45	0.68 ± 0.42	>0.05
Gingival	1.38 ± 0.52	1.32 ± 0.49	>0.05

DISCUSSION

The marginal integrity of composite restorations plays a pivotal role in determining their clinical longevity. Polymerization shrinkage and the stresses generated during curing remain significant concerns, particularly in posterior Class II restorations. This study aimed to evaluate whether bulk-fill composite resins differ from conventional incremental composites in terms of microleakage performance. The results of the present study demonstrated that both bulk-fill and conventional composite resins exhibited comparable microleakage at occlusal and gingival margins.[9] These findings are consistent with previous studies reporting no statistically significant difference in microleakage between bulk-fill and conventional composites. Studies by Ghosh et al. (2025)[10] and Hassan et al. (2024)[11] reported similar marginal sealing ability for bulk-fill composites, attributing this to reduced polymerization stress and improved depth of cure. The higher microleakage observed at gingival margins in both groups aligns with findings reported by numerous investigators. This can be explained by the anatomical and histological differences between enamel and dentin. Enamel provides a more favorable substrate for bonding, whereas dentin contains higher organic content and dentinal tubules, making adhesion more complex and less predictable.[12] Bulk-fill composites are designed to reduce polymerization stress through stress-relieving monomers and increased translucency, which allows deeper light penetration. Studies by Shihabi et al (2025)[13] and Ellithy et al (2024)[14] demonstrated that bulk-fill composites achieve adequate polymerization even at greater depths, supporting their use in posterior restorations. The comparable microleakage scores observed in the present study suggest that these material advancements effectively counteract the potential disadvantages of bulk placement.[15] Furthermore, the reduced placement time associated with bulk-fill composites offers a significant clinical advantage. Incremental placement requires multiple curing cycles, increasing the risk of contamination and void formation. By simplifying the restorative procedure, bulk-fill composites may reduce technique sensitivity and improve clinical efficiency.[16] Despite these advantages, it is important to acknowledge the limitations of in-vitro studies. Factors such as occlusal loading, pH fluctuations, and long-term degradation of the adhesive interface were not simulated in this study. Previous clinical studies have emphasized the importance of proper case selection and strict adherence to manufacturer guidelines when using bulk-fill composites.[11]

CONCLUSION

Within the limitations of this in-vitro study, bulk-fill composite resins demonstrated microleakage comparable to conventional incremental composite resins in Class II restorations. Bulk-fill composites may be considered a clinically acceptable alternative, offering similar marginal integrity with reduced operative time and improved procedural efficiency

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