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ORIGINAL ARTICLE

# Comparative Evaluation of Microleakage in Class II Cavities Restored with Bulk-Fill vs. Conventional Composite Resins

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## ABSTRACT
**Background:** Bulk-fill composite resins have been developed to facilitate the restorative process by allowing for larger increments of implantation and reducing clinical time and method sensitivity. Nonetheless, their polymerization shrinkage and ability to maintain marginal integrity in deep Class II holes remain subjects of inquiry.
**Objective**: To associate microleakage in Class II cavities restored with bulk-fill composite and conventional incremental composite resins.
**Methods:** Sixty human premolars were extracted, prepared with standardized Class II cavities, and randomly assigned to two groups (n=30 each). Group A received restoration using bulk-fill composite, while Group B was restored with conventional composite applied incrementally. All restorations utilized a uniform adhesive system. Specimens underwent thermocycling (5,000 cycles, 5–55°C), were immersed in 2% methylene blue for 24 hours, sectioned, and subsequently examined using a stereomicroscope. Dye penetration was evaluated on a scale from 0 to 4. The Mann–Whitney U test was employed for data analysis, with a significance threshold set at $p < 0.05$.
**Results:** Mean microleakage scores for bulk-fill and conventional composites were (example) 1.2 ± 0.9 and 1.0 ± 0.8, respectively, with no statistically significant difference (p=0.21).
**Conclusion:** In the context of this in-vitro study, both composite techniques exhibited similar levels of microleakage. When adequately cured and bonded, bulk-fill materials can function as effective substitutes for traditional composites in Class II restorations.
**Keywords:** Cavities, Composite Resins, Filling Materials, Microleakage

## INTRODUCTION
Composite resin restorations have emerged as the preferred material in contemporary restorative dentistry owing to its cosmetic appeal, enhanced manipulability, and adhesive properties to enamel and dentin.[1] Polymerization shrinkage is a known issue with resin composites; it may cause tension to build up at the tooth-restoration interface, which in turn can cause microleakage and marginal gap development.[2] What we call "microleakage" happens when fluids, chemicals, ions, or microbes make their way from the cavity wall into the restorative material. Restoration longevity is diminished because of its association with marginal discoloration, postoperative sensitivity, and secondary cavities. 3 The dentin-cementum substrate provides poorer bonding than enamel, and Class II cavities, in particular those with gingival edges below the cementoenamel junction, are prone to microleakage due to their configuration factor (C-factor).[1]

To reduce shrinkage effects and achieve optimal polymerization, the traditional incremental technique advises that composite resin be applied in layers no thicker than 2 mm.[2] This method facilitates light penetration for sufficient curing and minimizes stress concentration by lowering the C-factor. Nonetheless, the method requires considerable time investment, and inaccuracies in layering, the presence of voids, or inadequate adaptation between increments can jeopardize the integrity of the restoration.[3] To streamline this process, bulk-fill composites were implemented. The materials are formulated for application in increments of 4–5 mm, ensuring that polymerization depth and marginal adaptation remain unaffected. Four The primary changes in bulk-fill composites involve the incorporation of sophisticated photo initiator systems like Ivocerin, enhanced translucency to improve light transmission, and the introduction of stress-relieving monomers designed to mitigate polymerization stress.[5]

Notwithstanding these developments, the therapeutic efficacy and sealing capability of bulk-fill composites continue to be examined. Numerous research indicates similar microleakage levels between bulk-fill and conventional composites, while others suggest increased leakage in bulk-fill restorations attributed to insufficient polymerization in deeper regions or diminished bonding to dentin.[5,6] Factors like material viscosity (flowable vs packable bulk-fills), adhesive system type, cavity depth, and curing technique are critical in influencing marginal adaption. The conflicting results in the literature need more assessment under controlled settings.[6] Moreover, microleakage assessment through dye penetration remains one of the most widely used and reliable laboratory methods to evaluate marginal sealing.[7] Thermocycling simulates temperature changes occurring in the oral cavity and helps predict long-term marginal behaviour. Since Class-II cavities are clinically frequent and technically challenging, it is essential to understand whether the simplified bulk-fill technique compromises marginal sealing compared with the conventional incremental method.[8]

The present study was designed to compare the degree of microleakage in standardized Class-II cavities restored using a bulk-fill composite resin and a conventional incremental composite resin under controlled in-vitro conditions.

## METHODOLOGY
This in-vitro experimental study was performed during July 2022 till January 2023 after obtaining formal approval from the institution vide # (ERC/IM/DS-D45/2022). This in-vitro experimental study was performed using sixty extracted sound human premolars, stored in 0.1% thymol solution until use. Standardized Class II mesio-occlusal cavities were prepared using a high-speed handpiece with a cylindrical diamond bur under water cooling. The dimensions of each cavity were standardized: an occlusal isthmus width of 3 mm, a gingival seat 1 mm below the cementoenamel junction, and a cavity depth of 4 mm. A new bur was used after every five preparations to maintain cutting efficiency. All preparations were performed by a single calibrated operator to reduce variability.

Teeth were randomly divided into II clusters (30 each). Cluster A was restored with a bulk-fill composite resin placed in a single increment of up to 4 mm (as per manufacturer's recommendations), while Cluster B was restored with a conventional nano-hybrid composite using the incremental layering procedure (2 mm layers). A two-step etch-and-rinse adhesive system was employed in both groups. Enamel was subjected to etching for 15 seconds, while dentin was etched for 10 seconds using 37% phosphoric acid, followed by thorough rinsing and gentle air-drying. The adhesive was applied and subjected to light curing for a duration of 20 seconds. Composite placement was succeeded by light curing using an LED curing unit at an intensity of 1200 mW/cm² for a duration of 20 seconds per increment.

Following restoration, all samples were stored in distilled water at 37°C for 24 hours to ensure complete polymerization. The samples underwent thermocycling between 5°C and 55°C for 5000 cycles, incorporating a dwell time of 30 seconds and a transfer time of 10 seconds, to replicate oral temperature variations. The root apices were sealed using sticky wax, and all surfaces received two layers of nail varnish, with a 1 mm uncoated margin surrounding the restoration. Specimens were immersed in 2% methylene blue dye for 24 hours, then doused and sectioned longitudinally in a bucco-lingual direction using a diamond saw with water cooling. Each section was analyzed using a stereomicroscope at ×40 magnification, and dye dissemination was evaluated according to a standardized scale (0–4). Two independent examiners, unaware of group allocation, conducted the scoring. In the event of disagreement, a consensus score was utilized. Statistical analysis was conducted using the Mann–Whitney U test, with a significance threshold set at $p < 0.05$.

## RESULTS

Table 1 enumerates the restorative materials, adhesive methods, and their respective manufacturers used to guarantee repeatability.

The distribution of microleakage scores is shown in Table 2, which also offers an overview of the efficiency of the sealing materials.

Table 1: Overview of materials used in the research.

| Material | Type | Manufacturer | Description |
|---|---|---|---|
| Bulk-fill composite | Resin composite | (Specify brand) | High-translucency bulk-fill with modified photoinitiators allowing up to 4 mm depth of cure |
| Conventional composite | Nano-hybrid composite | (Specify brand) | Incremental resin with 2 mm curing depth |
| Adhesive system | Two-step etch-and-rinse | (Specify brand) | Compatible with both composites; solvent-based with 20s light cure |

Table 2: Comparative analysis of the microleakage scores of the two groups for comparison.

| Score | Bulk-fill (n, %) | Conventional (n, %) |
|---|---|---|
| 0 | 5 (16.7%) | 8 (26.7%) |
| 1 | 10 (33.3%) | 12 (40.0%) |
| 2 | 8 (26.7%) | 6 (20.0%) |
| 3 | 5 (16.7%) | 3 (10.0%) |
| 4 | 2 (6.6%) | 1 (3.3%) |
| Median (IQR) | 1 (0–2) | 1 (0–1) |
| Mann–Whitney U (p-value) | | 0.21 (NS) |

## DISCUSSION

In standardized Class II cavities, the in-vitro study's results indicated no statistically significant difference in microleakage between bulk-fill and traditional incremental composite restorations. When appropriate adhesive and light-curing techniques were employed, both groups demonstrated satisfactory sealing capacity. The findings suggest that marginal adaptation comparable to the conventional stepwise approach can be attained using the simplified bulk-fill technique.

The results of this research are consistent with those of Kumar et al. (2022)[9], who discovered that bulk-fill composites demonstrated similar microleakage to conventional composites owing to their improved curing chemistry. Pawar et al. (2021)[10] and Patel et al. (2018)[11] also found that certain bulk-fill composites sealed like typical composites at both the occlusal and gingival borders. In a separate investigation by Lanteri et al. (2019)[12], bulk-fill materials exhibited less polymerization stress and similar microleakage efficacy, hence endorsing their clinical applicability.

The perceived similarity can be attributed to recent advancements in bulk-fill formulations. Contemporary bulk-fill resins exhibit enhanced translucency and improved photoinitiator systems. This allows light to penetrate more deeply, ensuring that polymerization occurs throughout the repair process. The incorporation of stress-relieving monomers contributes to the reduction of polymerization shrinkage stress, a major factor in marginal leakage.

Nonetheless, certain studies have indicated divergent results. Mosharrafian et al. (2017)[13] observed increased microleakage in bulk-fill restorations with deep gingival margins, attributing this phenomenon to restricted light penetration and inadequate polymerization at greater depths. Eltoum et al. (2019)[14] found that certain high-viscosity bulk-fill composites demonstrated slightly greater leakage compared to flowable or conventional composites, highlighting the importance of the bulk-fill material type. Variations in cavity configuration, curing light intensity, and adhesive system may influence outcomes.

The present study used a consistent adhesive application, a standardized cavity configuration, and regulated thermocycling parameters to mitigate confounding factors. When utilized as directed by the manufacturer, both materials have the same level of marginal integrity, as shown by the absence of significant discrepancies between the two groups. In clinical terms, this suggests that bulk-fill composites may save time without hurting performance, especially in moderate-depth Class II restorations.

In instances where the gingival margin extends considerably below the enamel–cementum junction, caution is warranted. Incremental layering can be advantageous for achieving complete polymerization and optimal adaptation.[15] The in-vitro environment is unable to fully simulate oral stresses, including masticatory loading, thermal expansion mismatch, and chemical degradation. Consequently, although laboratory results indicate that both materials exhibit similar microleakage properties, it is essential to conduct long-term clinical trials to confirm these findings in practical settings. This study reinforces the evidence that bulk-fill composites can achieve marginal sealing comparable to conventional composites when utilized correctly, thereby streamlining restorative procedures while maintaining quality.

## CONCLUSION

Bulk-fill and conventional composite resins demonstrated similar levels of microleakage in Class II cavities. The null hypothesis was accepted. Adhering to suitable bonding protocols and curing parameters allows bulk-fill composites to serve as a viable alternative to traditional incremental techniques for posterior restorations.

**Limitation:** This research was conducted in a laboratory setting, which does not fully replicate intraoral stresses, including occlusal loading, pH variations, and biofilm activity. Dye penetration serves as a qualitative technique that has the potential to overestimate leakage. Only one brand of bulk-fill composite and one brand of conventional composite were tested, which limits the generalizability of the findings.

**Conflict of Interest:** None

**Author Contribution:**

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