# Efficacy of Fiber Inserts in Reducing Gingival Microleakage in Class II Composite Resin Restorations: An In Vitro Study

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## Abstract

Tooth-colored posterior restorations, particularly direct resin composites, have become the preferred treatment since their introduction in the 1960s. Improvements in materials and patient preferences for mercury-free alternatives have driven the adoption of composite resins over amalgam. However, issues such as polymerization shrinkage and microleakage, especially at the gingival margins of Class II cavities, remain significant challenges. This in vitro study assessed the gingival microleakage of Class II composite resin restorations with and without fiber inserts. Sixty freshly extracted intact molars were divided into three groups: Group I (control, no fiber insert), Group II (polyethylene fiber insert) and Group III (glass fiber insert). Cavities were restored using a single bond universal adhesive and a packable composite, then thermocycled, stained with methylene blue, sectioned and analyzed under a stereo microscope. Microleakage was scored based on dye penetration. The mean microleakage scores were significantly lower in the fiber-reinforced groups compared to the control group. Group I showed a mean score of 1.75±0.79, Group II had 0.95±0.60 and Group III had 0.80±0.52. Both fiber groups demonstrated significantly less microleakage than the control group ($p<0.05$), with no significant difference between the polyethylene and glass fiber groups, though the glass fiber group performed slightly better. Fiber inserts significantly reduce gingival microleakage in Class II composite resin restorations, with glass fiber inserts showing marginally better performance than polyethylene fibers. However, complete elimination of microleakage was not achieved. Further research is needed to optimize these materials and techniques for clinical use.

## INTRODUCTION

Tooth-colored posterior restorations, particularly direct resin composites, have become the treatment of choice for many patients since their introduction by Bowen in the early 1960[1]. Over the past two decades, significant improvements in these materials, coupled with decreasing patient acceptance of traditional amalgam, have contributed to the widespread adoption of resin composites as a viable alternative to amalgam in numerous countries[2]. This shift is largely due to the aesthetic advantages of composite resins, which can match tooth color and bond to tooth structure, their lack of mercury, and their overall biocompatibility[3,4].

Despite advancements in resin-based composites over the past decade, such as variations in polymerization methods, filler content, particle size, and composition, as well as innovations in dentin bonding agents, clinicians still face challenges with these materials. Historically, dentists have encountered issues such as poor wear resistance, difficulties in achieving good proximal contact and contour, polymerization shrinkage and inadequate dentin marginal adaptation when using resin-based composites for posterior restorations[5-7]. Although contemporary composites have shown significant improvements in wear resistance and proximal contact, polymerization shrinkage and microleakage, which can lead to postoperative sensitivity, recurrent caries, and potential restoration failure, remain significant challenges[8-11].

This study aims to assess and compare gingival microleakage in Class II composite resin restorations with and without fiber inserts. The null hypothesis is that adding a layer of fiber-reinforced composite (FRC) under composite restorations using polyethylene or glass fibers will reduce gingival microleakage in these restorations.

## MATERIALS AND METHODS

**Selection of Teeth:** Sixty freshly extracted intact human molars free of caries, attrition, abrasion, erosion, restorations and craze lines were selected for the study. The teeth were cleaned of any calculus, stains, soft tissue and other debris, then polished and stored in distilled water.

**Cavity Design:** Class II slot cavity preparations were performed on the proximal (mesial/distal) surfaces of each sample using a FG-169L taper fissure carbide bur (S.S. White, Germany) with a water-cooled high-speed air turbine handpiece. All line angles were rounded. The gingival margin of the Class II preparation was extended gingivally so that it lay at least 1 mm below the cemento-enamel junction on the root surface. Each bur was replaced after every five cavity preparations. Cavity dimensions were 3 mm wide buccolingually, 4.5-5.5 mm in height and the axial wall 1.5 mm deep. The preparation dimensions were measured with a periodontal probe. The enamel cavosurface margin was beveled at 45 degrees to 0.5 mm with a TF 11 diamond point (Mani).

**Restoration Groups:** The teeth were randomly assigned to three groups, each containing 20 samples, based on the restorative technique used:

- **Group I (Control Group):** No fiber inserts.
- **Group II:** Ribbond Triaxial Polyethylene fibers.
- **Group III:** Ever stick Ortho Glass fibers.

**Application of Bonding Agent:** A universal metal matrix band/retainer (Tofflemire) was placed around each prepared tooth and supported externally by applying low fusing compound to maintain adaptation of the band to the cavity margins. The cavity was cleaned with a water spray and air-dried for five seconds. The bonding agent (3M ESPE Single Bond universal adhesive) was applied to cavity walls using a disposable applicator. The adhesive was rubbed in for 20 seconds, air-dried for five seconds and light-cured for 10 seconds using a commonly used curing light.

**Restoring the Cavity with Composite Resin:**
**Group I:**

- An approximate 2 mm layer of P-60 (3M-Shade A3) was adapted onto the gingival floor (incremental technique) and light polymerized for 40 seconds.
- A second increment was added diagonally on one side and light polymerized for 40 seconds.
- Third and fourth increments were placed and light polymerized similarly.
- The occlusal surfaces were then finished and polished.

**Group II:**

- A piece of polyethylene fiber (Ribbond Triaxial) was cut to 3 mm in length and 1 mm in width, wetted with a few drops of bonding adhesive (Prime and Bond-Dentsply), blotted with lint-free gauze, and the solvents evaporated with an air syringe.
- Less than 1 mm thick resin composite (P-60 Shade A3) was placed on the gingival floor, followed by the fiber insert, which was light polymerized for 40 seconds.
- The remainder of the cavity was filled incrementally and light-cured as described for Group I.

**Group III:**

- A 3 mm long piece of glass fiber along with its silicone bedding (Ever Stick Ortho 0.75 mm in diameter) was cut using sharp scissors.
- Less than 1 mm thick resin composite (P-60 Shade A3) was placed on the gingival floor, followed by the glass fiber insert, which was light polymerized for 40 seconds.
- The remainder of the cavity was filled incrementally and light-cured as described for Group I.

**Finishing and Polishing:** All restorative materials were polymerized with OptiLite LD Max (Gnatus) LED curing unit in soft start mode. The restorations were finished and polished with Shofu Super-Snap (Shofu Inc, Kyoto, Japan) aluminum oxide discs of decreasing abrasiveness (coarse to superfine). The teeth were stored in distilled water at room temperature for two weeks.

**Thermocycling:** The restored teeth were thermocycled for 500 cycles at temperatures of 5°C±2°C and 55°C±2°C with a dwell time of 10 seconds in each water bath and a transfer time of 10 seconds between each bath.

**Assessment of Microleakage:** The samples were blotted dry with a paper towel and the root apices were sealed with sticky wax. The teeth were coated with two layers of nail varnish except for an area approximately 1 mm around the gingival margin of the restorations. The teeth were then immersed in 2% methylene blue dye for 24 hours at room temperature, removed and thoroughly rinsed.

The teeth were sectioned with a thin diamond disc (DFS, Germany) through the center of the restoration to yield two sections per tooth. The degree of dye penetration in each tooth was assessed under 20X magnification with a stereomicroscope (Olympus SZ40). Dye penetration scores were assigned based on an ordinal ranking system:

- **Score 0:** No dye penetration
- **Score 1:** Dye penetration up to the outer half of the gingival floor
- **Score 2:** Dye penetration up to the inner half of the gingival floor
- **Score 3:** Dye penetration extending through the gingival floor up to 1/3 of the axial wall
- **Score 4:** Dye penetration extending through the gingival floor up to 2/3 of the axial wall
- **Score 5:** Dye penetration extending through the gingival floor up to the DEJ level

Dye penetration at the restoration-tooth interface was scored for cervical margins only. The results were tabulated and subjected to statistical analysis using Kruskal-Wallis one-way Analysis of Variance and Mann-Whitney U tests.

## RESULTS AND DISCUSSIONS

**Gingival Microleakage Assessment:** The study evaluated the gingival microleakage in Class II composite resin restorations using different fiber inserts. The restorations were grouped as follows:

- **Group I:** Composite resin restoration with no fiber inserts (Control Group).
- **Group II:** Composite resin restoration with Ribbond Triaxial polyethylene fiber inserts.
- **Group III:** Composite resin restoration with Ever Stick Ortho glass fiber inserts.

**Microleakage Scores at Gingival Margin:**

**Mean Microleakage Scores:** The distribution of microleakage scores along with the mean score for each group are summarized in the table below:

Group III (Ever Stick Ortho glass fiber inserts) showed the lowest mean leakage score, followed by Group II (Ribbond Triaxial polyethylene fiber inserts), with Group I (no fiber inserts) exhibiting the highest mean leakage score.

**Statistical Analysis:**

**Kruskal-Wallis Test** A Kruskal-Wallis one-way analysis of variance was performed to detect any significant differences in microleakage among the three groups.

The Kruskal-Wallis test indicated significant differences between groups ($p<0.0001$).

**Mann-Whitney U Test:** The Mann-Whitney U test was used for intergroup comparisons:

**The Results Indicated That:**

- Group II (Ribbond Triaxial polyethylene fiber inserts) and Group III (Ever Stick Ortho glass fiber inserts) exhibited significantly less dye leakage than Group I (control group with no fiber inserts) ($p\geq 0.001$).
- There were no significant differences in leakage between Group II and Group III ($p>0.05$), though Group III showed slightly better results than Group II.

Incorporating fiber inserts, both Ribbond Triaxial polyethylene fibers and Ever Stick Ortho glass fibers, significantly reduced gingival microleakage in Class II composite resin restorations compared to no fiber

**Definition of Dye Penetration Scores**

| Score | Definition |
|---|---|
| 0 | No dye penetration |
| 1 | Dye penetration up to the outer half of the gingival floor |
| 2 | Dye penetration up to the inner half of the gingival floor |
| 3 | Dye penetration extending through the gingival floor up to 1/3 of the axial wall |
| 4 | Dye penetration extending through the gingival floor up to 2/3 of the axial wall |
| 5 | Dye penetration extending through the gingival floor up to the DEJ level |

| Group | 0 | 1 | 2 | 3 | 4 | 5 | Mean Score | Standard Deviation |
|---|---|---|---|---|---|---|---|---|
| Group I | 00 | 09 | 07 | 04 | 00 | 00 | 1.75 | 0.79 |
| Group II | 04 | 13 | 03 | 00 | 00 | 00 | 0.95 | 0.60 |
| Group III | 05 | 14 | 01 | 00 | 00 | 00 | 0.80 | 0.52 |

| Groups | No. of Samples | Mean Rank | Chi-Square Value | p-value | Result |
|---|---|---|---|---|---|
| Group I | 20 | 41.93 | 17.091 | 0.0002 | Significant |
| Group II | 20 | 26.53 | | | |
| Group III | 20 | 23.05 | | | |

**Group I vs. Group II**

| Group | N | Mean | Std. Deviation | Mann-Whitney U | p-value | Result |
|---|---|---|---|---|---|---|
| Group I | 20 | 1.75 | 0.79 | 96.000 | 0.00019 | Sig. |
| Group II | 20 | 0.95 | 0.60 | | | |

**Group I vs. Group III**

| Group | N | Mean | Std. Deviation | Mann-Whitney U | P Value | Result |
|---|---|---|---|---|---|---|
| Group I | 20 | 1.75 | 0.79 | 75.500 | 0.00017 | Sig. |
| Group III | 20 | 0.80 | 0.52 | | | |

**Group II vs. Group III**

| Group | N | Mean | Std. Deviation | Mann-Whitney U | P Value | Result |
|---|---|---|---|---|---|---|
| Group II | 20 | 0.95 | 0.60 | 175.50 | 0.42175 | Non-Sig. |
| Group III | 20 | 0.80 | 0.52 | | | |

inserts. However, none of the methods completely eliminated microleakage. The Ever Stick Ortho glass fiber inserts showed a slight, statistically insignificant improvement over the Ribbond Triaxial polyethylene fibers.

The restoration of posterior teeth with resin-based composite materials has gained popularity due to their aesthetic advantages and the development of advanced adhesive techniques. Despite significant improvements in these materials, issues like microleakage, particularly at the gingival margins of Class II cavities, remain a clinical challenge[1]. Microleakage can lead to postoperative sensitivity, recurrent caries and the eventual failure of restorations[2].

The problem of microleakage is exacerbated by the polymerization shrinkage inherent to resin composites, which can create gaps at the tooth-restoration interface. Efforts to mitigate this issue have included modifications in resin composite formulations, application techniques and the use of different bonding agents[3,4]. However, achieving a completely microleakage-free margin remains elusive. This study aimed to evaluate the effectiveness of fiber inserts in reducing gingival microleakage in Class II composite restorations.

Fiber inserts, such as polyethylene and glass fibers, have been proposed to enhance the mechanical properties of composite restorations and reduce polymerization shrinkage[5]. These fibers act as megafillers, displacing some of the composite resin and thus reducing the overall volume that undergoes polymerization shrinkage[6].

The results of the current study indicated that both polyethylene (Ribbond Triaxial) and glass fibers (Ever Stick Ortho) significantly reduced gingival microleakage compared to the control group with no fiber inserts. The mean leakage scores for the control group, polyethylene fiber group, and glass fiber group were 1.75±0.79, 0.95±0.60 and 0.80±0.52, respectively. These findings align with previous research that supports the efficacy of fiber inserts in reducing microleakage[7,8].

The reduction in microleakage observed with fiber inserts can be attributed to several factors. First, the fibers replace part of the composite increment, reducing the overall volumetric polymerization contraction. Second, the fibers assist the initial increment of the composite in resisting pull-away from the margins toward the light source, thus enhancing the marginal seal[9].

Glass fibers demonstrated slightly better performance than polyethylene fibers, although the difference was not statistically significant. This could be due to the light-transmitting properties of glass fibers, which improve the polymerization and physical properties of the composite resin[10].

Despite the promising results, the complete elimination of microleakage was not achieved, indicating that further research is needed. Future studies should explore the use of advanced microleakage testing methods, low-shrinkage composites and improvements in dentin adhesive systems. Additionally, clinical trials are necessary to validate these findings in vivo and to assess the long-term durability of fiber-reinforced composite restorations[11].

## CONCLUSIONS

In conclusion, while fiber inserts significantly reduce gingival microleakage in Class II composite restorations, they do not completely eliminate it. The use of polyethylene and glass fiber inserts offers a promising approach to improving the clinical performance of composite restorations, paving the way for further innovations in conservative dentistry.

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