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# Influence of Fiber Inserts, Type of Composite, and Gingival Margin Location on the Microleakage in Class II Resin Composite Restorations

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### Clinical Relevance

Using low-shrink composites and placing the gingival margin in enamel resulted in a significant reduction in microleakage in Class II resin composite restorations, thus probably improving clinical outcomes. Conversely, the use of fiber inserts had no influence on microleakage in Class II resin composite restorations.


## SUMMARY

**This study evaluated the influence of fiber inserts, type of composites, and location of the gingival seat on microleakage in Class II resin composite restorations. Fifty noncarious human third molars were selected for the study. Standardized Class II box type cavities were prepared on the mesial and distal side of 45 teeth. The gingival margin was placed above the cementoenamel junction (CEJ) on the mesial side and below the CEJ on the distal side. The remaining five teeth received no cavity preparations. The prepared samples were divided randomly on the basis of type of composite and presence or absence of fiber inserts, into four experimental groups of 10 teeth each and two control groups of five teeth each. The groups were defined as follows: group I (n=10) – Z350 XT; group II (n=10) – Z350 XT with fibers; group III (n=10) – P90; group IV (n=10) – P90 with fibers; and group V (n=5) – positive controls, cavities were not restored; group VI (n=5) – negative controls, no cavities were prepared. The samples were stored in distilled water in incubator at 37°C for 24 hours and then subjected to 500 cycles of**


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**thermocycling (5°C and 55°C) with a dwell time of 15 seconds. They were then placed in a 2% methylene blue dye solution for 24 hours at 37°C. Samples were sectioned longitudinally and evaluated for microleakage at the occlusal and gingival margin under a stereomicroscope at 20× magnification. Kruskal-Wallis and Mann-Whitney U-tests were used to compare the mean leakage scores. Restorations with gingival margins in enamel showed significantly less microleakage. Significant reduction in microleakage was observed in groups restored with P90 composite than those restored with Z350 XT. No improvement in microleakage was observed with the use of fiber inserts ($p>0.05$).**

## INTRODUCTION

Adhesion in dentistry has greatly expanded the horizon of esthetic dentistry. The resin composite materials have evolved in their properties. Superior esthetics, excellent workability, increased flexural modulus, and depth of cure have licensed their use in posterior teeth with greater reliability today, but they may still be unsuccessful clinically due to wear, poor strength, technique sensitivity, bond deterioration with time, polymerization shrinkage, and inadequate polymerization, especially in the gingival areas of Class II restorations.[1]

One of the major disadvantages of resin composites is polymerization shrinkage. This shrinkage results in the production of internal and interfacial stresses leading to gap formation at the tooth restoration interface leading to microleakage. A powerful tool to prevent this problem is adequate bonding of the resin composite to the cavity walls. If such bonding can be achieved, gap formation can be prevented.[2]

This problem is more pronounced when the margins of the resin restoration are in dentin/cementum. Due to their higher organic content, dentin and cementum are less favorable substrates for bonding. Microleakage due to gap formation can lead to a range of problems, like marginal staining, postoperative sensitivity, recurrent caries, and possible loss of the restoration.[3,4]

Efforts have been made to develop methods to prevent microleakage in Class II composite restorations by decreasing the polymerization shrinkage. These include: altering the curing technique[5]; reducing C-factor by following strategic incremental placement techniques[6]; using flowable composites under conventional composites; changing the resin composition, eg, increasing the filler loading of the resin; altering the filler particle size and shape; adding prepolymerized fillers; incorporating matrix expanding monomers[7]; and reinforcing composite with fiber inserts.

According to Xu and others,[8] when fiber inserts are placed in Class II composite restorations, they increase the quality of the marginal zone in two ways. First, the fibers replace the part of the composite increment at this location, which results in a decrease in the overall volumetric polymerization contraction of the composite. Second, the fibers assist the initial increment of the composite to resist pull-away from the margins towards the light source. The fibers may also have a strengthening effect on the composite margin, which may increase resistance to dimensional change or deformation that occurs during thermal and mechanical loading, thus, improving marginal adaptation.

Research in increasing the filler loading of the resin has led to the development of nanocomposites. The properties of nanocomposites seem to be equivalent or sometimes even better than hybrid composites and significantly better than microfilled composites.[9] According to the manufacturer, Z350 XT is a recently introduced resin composite based on nanotechnology, which provides excellent wear resistance, high tensile strength, and compressive strength to fracture.

Recently, Weinmann and others[7] described the synthesis of a promising new monomer system, ie, silorane, which is obtained from the reaction of oxirane and siloxane molecules. P90 is a recently introduced silorane-based low-shrink resin composite. According to the manufacturer, it is the first composite that shrinks less than 1%. It has excellent compressive strength, high flexural strength, and good wear resistance.

Over the past few years, new dental products containing glass, polyethylene, quartz carbon, or other fibers have been made available. These products are meant to improve the mechanical properties of the materials and provide extended applications for resin composites.

Glass fibers have demonstrated their ability to withstand tensile stress and stop crack propagation in composite material.[10] everStick NET fibers are silanated E-glass fibers impregnated with bisphenol A-glycidyl methacrylate and polymethyl methacrylate. everStick NET has a unique interpenetrating polymer network that provides it superior bonding

Table 1: *Manufacturers and Composition of the Materials Utilized in the Study*

| Products | Type | Composition | Manufacturer |
|---|---|---|---|
| Filtek Z350 XT | Nanocomposite | Organic matrix: Bis-GMA, UDMA, Bis-EMA 6, and small quantities of TEGDMA | 3M ESPE, St Paul, MN, USA |
| | | Inorganic particle: nonagglomerated nanoparticles of silica with a size of 20 nm and nanoagglomerates formed of zirconium/silica particles ranging from 0.6 to 1.4 mm in size, 78.5% by weight (59.5% by volume) | |
| Filtek P90 (silorane) | Matrix expanding composite | Silane treated quartz 60%-70%; yttrium trifluoride 5%-15%; Bis-3,4-epoxycyclohexylethyl-phenyl-methylsilane 5%-15%; 3,4-epoxycyclohexylcyclo-polymethylsiloxane 5%-15% | 3M ESPE, St Paul, MN, USA |
| everStick NET | Glass fiber | E-glass (electric glass, silanated), bis-GMA, and PMMA | Stick Tech, Turku, Finland |

*Abbreviations: Bis-EMA, ethoxylated bisphenol -A dimethacrylate; Bis-GMA, bisphenol -A glycidyl methacrylate; TEGDMA, triethylene glycol dimethacrylate; UDMA, urethane dimethacrylate; PMMA, polymethyl methacrylate.*

properties. No study has evaluated the effect of embedding glass fibers in silorane-based low-shrink composites on microleakage in Class II restorations.

The aim of this study was to evaluate the influence of fiber inserts, type of composites, and location of gingival margin on microleakage in Class II resin composite restorations.

## MATERIALS AND METHODS

Ethical committee clearance was obtained for performing this study. Fifty non carious human third molars that were freshly extracted were used in this study. Residual soft tissue was carefully removed with the help of ultrasonic scaler, and teeth were carefully examined to rule out any preexisting cracks. The teeth were then stored in distilled water with thymol crystals until use. The manufacturers and components of the materials utilized in this *in vitro* study are presented in Table 1.

Forty-five teeth were randomly selected and standardized Class II box-type cavities were prepared on mesial and distal sides of teeth using a straight fissure bur in a high-speed handpiece. No cavities were prepared on the remaining five teeth.

The dimensions of the cavities were buccolingual width of 2 mm and axial depth of 1.5 mm. The dimensions of the cavities were gauged using the periodontal probe and a customized straight probe with a 1.5-mm marking. The gingival seat was placed 1 mm above the cementoenamel junction (CEJ) on the mesial side and 1 mm below the CEJ on the distal side of each tooth.

Of 45 teeth that received cavity preparation, 40 teeth were randomly assigned for the experimental group and five for the positive control group. The teeth that did not receive any cavity preparation were assigned as negative controls.

The teeth in the experimental group were then randomly divided into four groups as follows:

- Group I (n=10): Samples were restored with packable composite Filtek Z350 XT.
- Group II (n=10): Samples were restored with packable composite Filtek Z350 XT reinforced with everStick NET fibers.
- Group III (n=10): Samples were restored with low-shrink composite Filtek P90.
- Group IV (n=10): Samples were restored with low-shrink composite Filtek P90 reinforced with everStick NET fibers.
- Group V: Positive control (n=5), the cavities were not restored.
- Group VI: Negative control (n=5), no cavities were made.

The cavity on the mesial and distal side of all samples was acid etched for 15 seconds and then rinsed with water from the three-way syringe and gently dried using a moist cotton pellet. The intensity of the quartz-tungsten-halogen (QTH) light was set at 600 mW/cm$^2$ and was verified with the built-in radiometer. Dentin bonding agent (Adper Single Bond 2) was applied with the help of a microbrush and light cured for 10 seconds from the occlusal aspect. Before restoration, universal Tofflemire band and retainer was positioned. Approximately a 1-mm increment of the resin composite was first placed on the gingival floor with the help of a Teflon-coated composite instrument and light cured for 40 seconds from the occlusal aspect. The second increment was added along the buccal wall in an oblique direction and light cured for 40 seconds. The third increment was placed along the lingual wall obliquely and light cured for 40 seconds. The final increment was added to fill the remainder of the cavity and light cured for 40 seconds. The intensity of the QTH light was verified after restoration of each cavity.

In the samples of groups II and IV, after acid etching and application of the bonding agent, a 1-mm increment of the resin composite was placed on the gingival floor. Then, a $1.5 \times 2.0$ mm piece of everStick NET fiber was placed onto the composite increment and condensed through it to adapt it against the gingival floor, displacing the composite to fill into the corners of the box. It was then light cured for 40 seconds from the occlusal aspect. The rest of the cavity was restored as described above.

All of the specimens were then stored in distilled water in an incubator at 37°C for 24 hours. The teeth were then subjected to thermocycling (5° to 55°, 500 cycles) with a dwell time of 15 seconds in electronically maintained water baths.

Light-cured glass ionomer cement (Fuji 2 LC, GC Corporation, Tokyo, Japan) was then applied on apices of all the teeth and light cured for 40 seconds to seal the apices.

In the samples of groups I to V, two coats of nail varnish were applied on the teeth leaving a 1-mm window all around the gingival margin. The teeth in group VI (negative controls) were coated with two coats of nail varnish around the entire surfaces. The teeth were then immersed in 2% methylene blue dye solution for 24 hours at 37°C.

After removal from the dye, the specimens were rinsed thoroughly in tap water. The teeth were then sectioned longitudinally along the mesiodistal plane, cutting through the center of the mesial and distal cavities using a low-speed diamond disc.

The extent of dye penetration at the gingival margin on both sides was evaluated by examination under a stereomicroscope at a magnification of 20× (Olympus, Spectro Analytical Laboratory, New Delhi India), according to a six-point scale: 0 = no leakage, 1 = leakage extending to the outer half of the gingival floor, 2 = leakage extending to the inner half of the gingival floor, 3 = leakage extending through the gingival floor up to one third of the axial wall, 4 = leakage extending through the gingival wall up to two thirds of the axial wall, and 5 = leakage extending through the gingival wall up to the DEJ level.

The results were statistically analyzed using SPSS version 10.0. The scoring was done using an ordinal scale; hence, a nonparametric evaluation plan was adopted. Kruskal-Wallis test (nonparametric analysis of variance [ANOVA]) was carried out to compare leakage scores of different groups (type of composites and with and without fiber reinforcement). To verify whether the location of the gingival margin would influence the marginal leakage scores, regardless of the type of composites and fiber reinforcement, the Mann-Whitney U-test was used to compare enamel and dentin margins. Multiple linear regression analyses was applied to quantify the effect of independent variable factors on leakage score. A $p$-value of $< 0.05$ has been considered statistically significant.

## RESULTS

The mean dye penetration and its standard deviation along with its number of observation in each experimental group were compared, and the results are tabulated in Table 2. All of the negative controls invariably had a score of 0 (minimum score) at both locations, while all positive controls invariably had a score of 5 (maximum score) at both locations; hence, intergroup comparison was restricted to the test groups only.

P90 (low-shrink composite) provides a significantly better marginal seal than Z350 XT (nanocomposite) in Class II resin restorations. Composites (Z350 XT and P90) with fiber inserts performed slightly better than composites without fibers; however, the difference was statistically insignificant. Restorations having gingival margins in enamel showed significantly less microleakage than those having gingival margins in cementum.

In the present study, of the three variables, the type of composite had the greatest influence on the microleakage, followed by the location of the gingival margin. Reinforcing the composite with glass fibers had the least effect.

## DISCUSSION

The greatest limitation in the use of composite restoration as a posterior restorative material seems to be shrinkage during polymerization, which leads to poor marginal seal and microleakage.[11] This problem is more conspicuous when the gingival margins of the tooth preparation lie below the

Table 2: *Mean ± SD and Statistical Comparison Between Groups*[a]

| Groups | Dye Penetration Leakage | | | Statistically Significant Difference Between the Groups | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | Mean | SD | Z350/EM | Z350/CM | Z350+FI/EM | Z350+FI/CM | P90/EM | P90/CM | P90+FI/EM | P90+FI/CM |
| Z350/EM | 10 | 3.1 | 0.568 | 1 | .014 | 0.57 | — | <0.001 | — | <0.001 | — |
| Z350/CM | 10 | 4.0 | 0.667 | | 1 | — | 0.57 | — | 0.001 | — | <0.002 |
| Z350+FI/EM | 10 | 2.9 | 0.738 | | | 1 | 0.012 | <0.001 | — | <0.001 | — |
| Z350+FI/CM | 10 | 3.9 | 0.738 | | | | 1 | — | <0.002 | — | <0.001 |
| P90/EM | 10 | 1.4 | 0.516 | | | | | 1 | <0.001 | 0.075 | — |
| P90/CM | 10 | 2.7 | 0.675 | | | | | | 1 | — | 0.070 |
| P90+FI/EM | 10 | 0.8 | 0.632 | | | | | | | 1 | 0.036 |
| P90+FI/CM | 10 | 1.8 | 1.033 | | | | | | | | 1 |

*Abbreviations: CM, cementum margin; EM, enamel margin; FI, fiber inserts.*
[a] $p<0.05$ *considered statistically significant.*

cementoenamel junction. Microbial microleakage, an important sequel of polymerization shrinkage has been identified as a major factor in the pulpal reaction to composite resin restorations.[12]

For evaluation of microleakage, the 2% methylene blue dye penetration method was used in this study because it is a simple and inexpensive technique and has shown better penetration results than eosin or the radioisotope tracers Ca and labelled calcium chloride, c-labeled urea, and I-labeled albumin.[13,14] Methylene blue has a low molecular weight, and its molecular size is smaller compared to the diameter of dentinal tubules (1-4 μ) as well as bacteria (2-4 μ), allowing it to penetrate easily into the dentinal tubules, mimicking the passage of bacterial toxins into the dentinal tubules.[15]

In this study, greater microleakage was observed for the restorations with margins in cementum than for the restorations with margins in enamel. This finding is in accordance with the results of Araujo and others[1] and Tredwin and others[16] who reported that restorations with margins in cementum/dentin leaked significantly more than those with margins in enamel**.** The variation in the microleakage of enamel and cementum margin can be explained by the structural differences in the substrate. Dentin and cementum present a higher percentage of water and organic material than enamel, which makes it difficult to obtain a consistent adhesion capable of resisting the negative effects of polymerization shrinkage and the subsequent mechanical and thermal stresses.[1] Moreover, in clinical scenarios, the hydration level and the movement of dentinal tubular fluids may also interfere with the bonding of the resin composite with dentin.[17]

In the current study, the use of fibers did not significantly improve the microleakage scores, which is in accordance with the results of Tani and others,[18] Donly and others,[19] and Applequist and Meiers.[20] They found no significant improvement in microleakage with the use of glass inserts in Class II composite restorations.

However, the present finding is contrary to the results of Ozel and Soyman[21] who demonstrated significantly less dye penetration in restorations reinforced with fibers than restorations without fibers. The difference in the results of their study and the present study could be because glass fibers in their study were adapted through a flowable composite increment placed on the gingival seat, which could have improved the adaptation of the fibers to the cavity walls.

Results contradictory to the present study have also been reported by El-Mowafy and others[10] and Basavanna and others.[22] In their studies, they demonstrated significant reduction in dye penetration when glass fibers were used to reinforce a packable composite, P60. This difference could be because of the different type of composite used in their study.

Low-shrink composite P90 demonstrated significantly less microleakage than Z350 XT in the present study. This is in agreement with a study of Bagis and others[23] who compared silorane with nanohybrid composite (Gradio) and found silorane-based microhybrid composite to have no microleakage. Papadogiannis and others[24] and Bogra and others[25] also reported that silorane material showed better behavior than dimethacrylate materials in setting shrinkage and marginal adaptation. The probable reason for this may be attributed to difference in filler loading,[24,26,27] filler size,[24,27] or volumetric polymerization shrinkage.[25]

P90 composite is a silorane-based composite. It polymerizes by a cationic ring opening mechanism. Such a polymerization is attributed as "living" or "dark" polymerization. The reactive species in such a reaction do not extinguish as quickly as the free radicals contained within methacrylate-based resins. This results in slower rates of polymerization allowing stress relaxations during composite polymerization, thereby reducing polymerization shrinkage and associated stress.[28] P90 has a net volumetric shrinkage of less than 1%. On the other hand, Z350 XT is a nanocomposite, which has a net volumetric shrinkage of about 1.7%. The silorane-based composites are believed to withstand the fatigue at the tooth restoration interface better than the nanofilled and microfilled composites.

Moreover, Z350 XT has higher filler loading of 78.6% than P90, which has filler loading of 76%.[29,30] The filler load has a positive influence on polymerization shrinkage, but on the other hand, affects polymerization shrinkage strain negatively,[31] which might explain greater microleakage observed with Z350 XT.

## CONCLUSIONS

According to the results, it is possible to conclude that:

1) P90 provides a significantly better marginal seal than Z350 XT in Class II resin restorations.
2) Composites with fiber inserts performed slightly better than composites without fibers. However, the difference was not statistically significant.
3) Restorations having gingival margins in enamel showed significantly less microleakage than those in cementum.

Further clinical trials are required to assess the success of low-shrink composites and reinforcement with glass fiber inserts in Class II composite restorations.

### Conflict of Interest

The authors of this manuscript certify that they have no proprietary, financial, or other personal interest of any nature or kind in any product, service, and/or company that is presented in this article.

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