



Role of TiF4 in Microleakage of Silorane and Methacrylate-based Composite Resins in Class V Cavities

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ABSTRACT

Aim: This study investigated the effect of TiF4 solution pretreatment on microleakage of silorane and nanofilled methacrylate-based composites in class V cavities.

Materials and methods: Forty-eight intact premolar teeth were randomly allocated to four groups of 12 teeth. Restorative techniques after standard class V tooth preparations were as follows: Group 1, Filtek P90 composite; group 2, Filtek Z350 XT; group 3, TiF4 solution pretreatment and Filtek P90 composite; group 4, TiF4 solution pretreatment and Filtek Z350 XT. After storing the specimens in distilled water at 37°C for 24 hours and followed by immersion of the specimens in a 0.5% basic-fuchsin solution for 24 hours, they were sectioned buccolingually to obtain four surfaces for each specimen for analysis of microleakage using a stereomicroscope. Data analysis was performed using Kruskal-Wallis test to compare the four groups and the Mann-Whitney test for paired comparisons with Statistical Package for the Social Sciences (SPSS) version 17 software.

Results: At the enamel margins, microleakage score of the Filtek Z350 XT group was lower than those of the Filtek P90 with and without the application of the TiF4 ($p=0.009$ and $p=0.031$ respectively). At the dentin margins, groups 3 and 4 (TiF4+Filtek P90 and TiF4+Filtek z350 XT respectively) showed significantly

lower microleakage than group 1 (Filtek P90). However, there was no significant difference between other groups ($p>0.05$).

Conclusion: At the enamel margins, microleakage score of the silorane-based composite was more than that of the nanofilled composite. No significant differences were observed between the other groups. At the dentin margins, for the silorane-based composite restorations, TiF4 solution pretreatment resulted in significantly lower microleakage. However, the similar result was not observed for Filtek Z350 XT. Also, no significant difference was observed between microleakage scores of Filtek P90 and Filtek Z350 XT with or without TiF4 pretreatment.

Clinical significance: In spite of better mechanical and physical properties of modern composites than earlier methacrylate-based composites, polymerization shrinkage has been remaining as one of the main shortcomings of them. Different methods, such as using new low shrinkage resin composites and different dentin pretreatments, have been suggested to overcome this problem. This study evaluated the effect of TiF4 as pretreatment on microleakage of class V tooth preparations restored with a nanocomposite and a silorane-based resin composite.

Keywords: Laboratory research, Nanofilled composite silorane composite, TiF4.

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INTRODUCTION

Composite resin restorative materials have been widely used in dental practice.¹ Although they have improved greatly since their introduction, some of the shortcomings of composite materials have not been overcome. Several researches focused on diminishing polymerization shrinkage, considered as one of the main shortcomings of the resin composites.² Debonding at the composite/tooth

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interface, recurrent caries, marginal staining, enamel fracture, and postoperative sensitivity are among consequences of polymerization shrinkage and the resultant contraction stress.^{3,4} To minimize polymerization shrinkage or limit the effects of it at the cavosurface margins, some restorative techniques, such as application of an intermediate low modulus liner between the prepared tooth structure and the resin composite,⁵ using an initial low-intensity curing light exposure,³ incremental placement of the restorative material⁵ application of a thicker layer of a low-modulus adhesive system,⁶ and development of new adhesives forming more efficient and resistant interfaces between resin composites and dental tissues⁷ have been suggested. However, the efficacy of some of these time-consuming clinical approaches to diminish polymerization shrinkage remains controversial.^{8,9} In the face of these difficulties, modifications in formulations of the resin composites, such as an increase in molecular weight per reactive group, an increase in the filler content, using different monomer structure and chemistry or changes in filler amount, shape, size, or surface treatment have been made frequently by manufacturers.^{10,11} Recently, a new type of ring-opening monomer named silorane with an arrangement of siloxanes and oxiranes has been developed to overcome problems associated with polymerization shrinkage. Silorane-based composites have low polymerization shrinkage (0.99 vol% against 1.5–6% of contraction observed in methacrylate-based composites) and stress and are highly reactive, hydrophobic, and biocompatible.^{10,12,13} Moreover, insolubility in biological fluid simulants, good stability in aqueous environments, and lower cuspal deflection compared with a methacrylate-based composite have been reported for them.^{12,14} They also show less degradation of the bond interface because of their highly hydrophobic properties.¹⁵

Recently, in an attempt to improve the properties of resin composites, nanocomposites were manufactured using nanotechnology and released onto the market. They offer high polishability, high polish retention, high translucency, proper maintenance of physical properties, and high wear resistance.¹⁶

Fluoridated products, such as sodium fluoride and titanium tetrafluoride (TiF₄) are among materials indicated for dentin pretreatment before adhesive application to decrease the possibility of secondary caries lesion formation by enhancing dentin remineralization and diminishing dentin solubility.¹⁷ Also, increased fluoride uptake was found following application of TiF₄ due to the presence of polyvalent metal ion forming strong fluoride complexes firmly bound to organic content or to the apatite crystals.^{18,19} Several studies demonstrated the efficacy of topically applied TiF₄ to reduce caries

demineralization and progression as well as to prevent erosion and abrasion lesions.^{17,20,21} Its protective action may be attributed to the formation of an acid-stable glaze-like surface layer composed of titanium oxide or of organometallic complexes.^{22,23} After hydrolysis of TiF₄ at low pH, the released titanium with a strong affinity to bound with an oxygen atom of a phosphate group on the tooth surface forms this layer of titanium-containing material coupling so tightly that it cannot be easily substituted.^{24,25} Only partial demineralization limited to the outermost 1 to 5 μm of the dentin surface was observed after application of TiF₄ as dentin pretreatment before adhesive application although TiF₄ solution has a highly acidic pH (about 1).²⁶ Moreover, TiF₄ has been recommended for reducing dentin hypersensitivity due to the dentinal tubule occlusion after its application.^{23,27} Titanium tetrafluoride can also prevent further dissolution and disintegration of the smear layer when applied as a dentin pretreatment before adhesive applications due to its protective effect against enzymatic activity on dentin that may be effective in inhibiting nanoleakage and hybrid layer degradation.^{26,28} According to a study by Devabhaktuni et al,²⁹ TiF₄ application did not compromise the bond strength of a resin composite to dentin when applied before and after acid etching with a conventional three-step adhesive system. In a literature review by Wiegand et al,³⁰ it was suggested that TiF₄ have protective effect against formation of the carious and erosive enamel and dentin lesions equally or even more than sodium fluoride (NaF), amine fluoride (AmF), or stannous fluoride (SnF₂). Moreover, Bridi et al³¹ concluded that dentin pretreatment with a TiF₄ solution did not affect the microtensile bond strength values of the self-etch adhesive systems used in their study.

To the extent of the authors' knowledge, although the preventive action of TiF₄ on dental caries or enamel and dentin erosion is well known,^{17,20,21} studies evaluating the effect of TiF₄ on microleakage of composite restorations are missing as yet. Therefore, this study aimed to evaluate the influence of TiF₄ as dentin pretreatment on microleakage of class v tooth preparations restored with new resin composites such as nanocomposites and silorane-based resin composites.

MATERIALS AND METHODS

After approval of the study design by the local ethics committee for research, 46 caries free teeth previously examined under a stereoscopic microscope (Carl Zeiss, Oberkochen, Germany) for the absence of the fracture, crack, previous restorations, abrasion, or structural deformities were assigned for this study. The specimens were cleaned with a periodontal curette and stored

in 0.5% chloramine solution at 4°C and used within 6 months after extraction. Class V cavities (1.5 mm in depth, 2 mm in height and 3 mm in width with the gingival cavosurface margins placed 1 mm below the CEJ and occlusal cavosurface margins located 1 mm above the CEJ) were prepared in the buccal surfaces of all the specimens using a fissure diamond bur (Diamond fissure 330; SS White) in a high-speed handpiece under sufficient water cooling with the cavity margins being located in both dentin and enamel. The bur was replaced after every four preparations. A periodontal probe (PCP UNC 127, Hu Friedy Mfg. Co. Inc., Chicago, IL) was used to check the cavity sizes after tooth preparations. After cleaning the cavities with pumice paste and rinsing them with a water spray, they were gently air-dried.

According to the presence or absence of pretreatment with TiF4 solution and the restorative material used, the specimens were randomly allocated to 4 groups of 12 teeth each.

For the group receiving dentin pretreatment with TiF4 solution (groups 3 and 4), based on the protocol described by Dündar et al,²⁸ TiF4 powder (Sigma-Aldrich, USA) was dissolved in deionized distilled water to prepare the solution freshly prior to application. PH of this solution was adjusted to 1.4 and measured by a pH electrode (Metron 827 pH Lab, Metron, Herisau, Switzerland) and the final concentration of it was 2.5% (wt/v). The prepared solution was applied actively on the internal walls of the cavity preparations for 60 seconds using a disposable brush followed by gentle air drying for 5 seconds.

In groups 1 and 3, the prepared class V cavities were etched with 37% phosphoric acid (3M ESPE, St Paul, MN)

for 20 seconds. After rinsing for 10 seconds and gently air drying for 5 seconds, in group 1, Adper Single Bond (SB, 3M ESPE) adhesive system was applied according to manufacturer’s instructions (Table 1) and cured for 10 seconds. In group 3, before application of the adhesive system, TiF4 solution was applied on the internal walls of the cavity preparations according to the aforementioned protocol. Subsequently, the cavities were restored using a nanocomposite (Filtek Z350 XT; 3M Dental Products, St Paul, MN) following the incremental technique (1 mm thick layers). Each increment was cured for 40 seconds using a light curing unit (VIP Junior, Bisco, Schaumburg, IL) at 600 mW/cm².

In groups 2 and 4, a silorane-based composite (Filtek P-90, 3M Dental Products, St. Paul, MN) was used for restoration of the cavities using an incremental technique after application and light activation of its respective self-etch primer and adhesive system according to the manufacturer’s instructions (Table 1). Before application of the silorane system self-etch primer in group 4, TiF4 solution was applied based on the aforementioned procedure. After storing the specimens in distilled water at 37°C for 24 hours, their root apices were sealed with utility wax, and all the surfaces, except for the composite restorations and 1 mm area around the occlusal and gingival margins of the restorations, were covered with two layers of nail varnish followed by immersion of the specimens in a 0.5% basic-fuchsin solution for 24 hours. Subsequently, the specimens were rinsed thoroughly and sectioned buccolingually with a water-cooled diamond saw (Leitz 1600, Wetzlar, Germany) to obtain four surfaces for each specimen (two in enamel and two in dentin)

Table 1: Composition and protocol for use of the materials used in this study

Material/Manufacturer	Main composition	Protocol for use
Adper Single Bond/3M ESPE, St Paul, MN, USA	Adhesive: Bis-GMA, HEMA, poly-alcenoic copolymer, Ethanol, water	Acid etching for 20 second. Rinse for 10 second. Apply two consecutive coats of adhesive; gentle air-dry the surface for 5 second and light cure for 10 second.
Silorane Adhesive System/3M ESPE, St Paul, MN, USA	Primer: 15–25% HEMA; 15–25% Bis-GMA; 10–15% water; 10–15% ethanol; 5–15% methacryl-oxy-hexyl-esters of phosphoric acid; 8–12% silanized silica; 5–10% 1,6-hexanediol dimethacrylate; <5% (dimethylamine) ethyl methacrylate ; <5% copolymer of itaconic and acrylic acids; <3% phosphine oxide; <3% DL-camphorquinone; Bond: 70–80% dimethacrylate substituted; 5–10% TEGDMA; 5–10% silanized silica; <5% methacryl-oxy-hexyl-esters of phosphoric acid; <3% DL-camphorquinone; 1,6-hexanediol Dimethacrylate; <5% (dimethylamine) ethyl; <5% copolymer of itaconic and acrylic acids	Active Primer application for 15 second Drying with air. Light activation for 10 second. Drying with air. Application of bond. Light activation for 10 second.
Filtek Z350/Composite resin (Shade A3)/ 3M ESPE, St Paul, MN, USA	Bis-GMA, UDMA, TEGDMA,, Bis-EMA Fillers (78.5%W, 59.5% V): Combination of Aggregated zirconia/ silica cluster filler, non- agglomerated/ non- aggregated 20 nm silica filler, non- agglomerated / non-aggregated 4-11 nm zirconia filler.	Filtek Z350 XT composite resin was applied following the incremental technique (1 mm thick layers) and each increment was light cured for 40 second.
Filtek P90/Composite resin (Shade A3)/3M ESPE, St Paul, MN, USA	5–15% of 3, 4-epoxy cyclohexyl cyclopolymethyl siloxane; 5–15% of 3, 4-epoxy cyclohexyl cyclopolymethyl siloxane; 50–70% silanized quartz; 10–20% Yttrium, Fluoride, camphorquinone.	Filtek P90 composite resin was applied following the incremental technique (1 mm thick layers) and each increment was light cured for 40 second.

Table 2: Microleakage scoring criteria used in this study

Microleakage score	Criteria
0	No dye penetration
1	Dye penetration up to one-half of the gingival or occlusal wall
2	Dye penetration up to the end of occlusal or gingival walls and not extending to the axial walls
3	Dye penetration extending to the axial walls

Table 3: Microleakage score of class V restorations

	Enamel				Dentin			
	Score 0	Score 1	Score 2	Score 3	Score 0	Score 1	Score 2	Score 3
	Group 1	10	9	5	0	7	12	5
Group 2	18	6	0	0	10	10	4	0
Group 3	11	11	2	0	15	8	1	0
Group 4	17	4	3	0	14	9	1	0

for analysis of microleakage and marginal gap. Dye penetration indicating microleakage was determined using a stereomicroscope (Carl Zeiss, Oberkochen, Germany) blindly by two calibrated and blinded evaluators at 50× magnification. The microleakage score was recorded as the following (Table 2):

- No dye penetration
- Dye penetration up to the one-half of the gingival or occlusal wall
- Dye penetration up to the end of the occlusal or gingival walls and not extending to the axial walls
- Dye penetration extending to the axial walls.

Statistical analysis of the data was performed using Kruskal-Wallis test to compare the four groups and the Mann-Whitney test for paired comparisons with Statistical Package for the Social Sciences (SPSS) version 17 software.

RESULTS

Microleakage scores at the enamel and dentin margins of class V composite restorations are listed in Table 3.

Kruskal-Wallis test showed significant differences among the four groups in the enamel and dentin margins (p=0.031 and p=0.037 respectively). The results of the Mann-Whitney test for paired comparisons are presented in Table 4. At the enamel margins, microleakage score of the Filtek Z350 XT group was lower than those of the Filtek P90 with and without the application of the TiF4 (p=0.009 and p=0.031 respectively). At the dentin margins, groups 3 and 4 (TiF4+Filtek P90 and TiF4+Filtek z350 XT respectively) showed significantly lower microleakage than group 1 (Filtek P90). However, there was no significant difference between other groups (p>0.05).

DISCUSSION

The results of the present study showed that at the enamel margins, microleakage score of the silorane-based

composite (with or without the application of the TiF4) was more than that of the nanofilled composite. At dentin margins, no significant difference was observed between microleakage scores of Filtek P90 and Filtek Z350 XT with or without TiF4 pretreatment. Also, TiF4 solution did not affect the microleakage scores of the nanofilled and silorane-based composites at the enamel margin in this study. At the dentin margins, for the silorane-based composite restorations, TiF4 solution pretreatment resulted in significantly lower microleakage. However, the similar result was not observed for Filtek Z350 XT.

An essential property of the adhesive bonding system to prevent pulp-dentin complex from exposure to bacteria and their products is the quality of resin-dentin or resin-enamel interface sealing.³² In spite of better mechanical and physical properties of modern composites than earlier methacrylate-based composites, polymerization shrinkage has been remaining as one of the main shortcomings of them.^{33,34} Generally, resin composite polymerization shrinkage stresses have been addressed as a destructive factor to the marginal sealing of the resin composite to tooth structure.³³ Among the various solutions mentioned to overcome this problem is to use silorane-based resin composites that have demonstrated lower polymerization shrinkage than methacrylate-based resin composites.¹⁰ Additionally, lesser microleakage than methacrylate-based composite restorations or no microleakage in wide class II MOD restorations with oblique and vertical layering technique have been reported for silorane-based composites.^{14,35} However, Usha et al³⁶ showed that although all class V cavities restored with the silorane-based resin composite showed some degree of microleakage, it could be minimized by using split incremental technique.

Recently, nanotechnology was used to release nanocomposites onto the market. This technology produces functional materials in the range of 0.1 to

Table 4: Statistical analysis of the microleakage scores

	Group 1–2	Group 1–3	Group 1–4	Group 2–3	Group 2–4	Group 3–4
Enamel	(p=0.009) p<0.05*	(p=0.534) p>0.05	(p=0.063) p>0.05	(p=0.031) p<0.05*	(p=0.577) p>0.05	(p=0.160) p>0.05
Dentin	(p=0.409) p>0.05	(p=0.013) p<0.05*	(p=0.023) p<0.05*	(p=0.103) p>0.05	(p=0.163) p>0.05	(p=0.782) p>0.05

*p<0.05 was significant

100 nm.¹⁶ Nowadays, there is an upward trend toward using nanocomposites between dental practitioners because of their beneficial properties such as offering high polishability, high polish retention, high translucency, proper maintenance of physical properties, and high wear resistance.¹⁶ In a clinical study by Dresch et al,³⁷ Filtek-Supreme, a nanofilled resin composite, revealed similar performance to packable and microhybrid composites in posterior teeth. However, in a clinical study by Ernst et al,³⁸ a higher percentage of color mismatch was shown for Tetric Ceram (a microhybrid composite) than Filtek Supreme.

In a study by Arslan et al,³⁹ the microleakage of a silorane-based composite was compared with that of a nanofilled methacrylate-based composite and it was concluded that chemical composition of the resin composite did not affect the microleakage. This result may be attributed to the characteristic features of methacrylate-based nano-filled composites that are formulated to show low levels of shrinkage.³⁹ However, some studies have reported lower microleakage for silorane-based restorative systems than methacrylate-based systems.^{40,41} Yamazaki et al⁴² compared the microleakage of a new low shrinkage resin composite with a hybrid resin composite and a nanofilled resin composite and found some degree of leakage in all three resin composite materials. However, in the current study, at the enamel margins, microleakage score of the silorane-based composite (with or without the application of the TiF4) was more than that of the nanofilled composite. At dentin margins, no significant difference was observed between microleakage scores of Filtek P90 and Filtek Z350 XT with or without TiF4 pretreatment.

A special self-etching adhesive system is used for the silorane-based composites. The silorane light-cured, one-step self-etching primer is hydrophilic and acidic with a pH of 2.7 that may be considered as a one-step adhesive system. This mild self-etching primer demineralizes dentin no deeper than few hundreds of nanometers. After primer application, a more viscous and hydrophobic resin adhesive is applied and light cured. Due to the high concentration of the 2-hydroxyethyl methacrylate in the silorane primer to prevent separation of the primer phases, the silorane primer is vulnerable to water sorption. In contrast, the silorane resin adhesive is extremely hydrophobic resulting in the presence of water exactly between the layers of the primer and the resin adhesive.¹⁵ Considering these points, the adhesive interface may act as the weak link of the adhesive system leading to reduced bond strength.⁴³ The aforementioned explanation may justify the higher microleakage values of silorane-based composite restorations at enamel margins than the nanofilled composite restorations in the

present study. Also, another considerable factor is that the lower degree of polymerization shrinkage does not necessarily lead to a lower degree of stress generation and gap formation at the bond interface of the composites.⁴⁴ This fact is due to the high modulus of elasticity of P90 compared with methacrylate-based composites with similar fillers.⁴⁵ Moreover, low etching efficacy of self-etch adhesives and their questionable bonding ability to enamel⁴⁶ may justify greater microleakage values for the silorane-based composite than the nanofilled composite at enamel margin in this study. In contrast, at dentin margin, microleakage of the silorane-based composite and nanofilled composite was the same.

As discussed previously, TiF4 solution application as a dentin pretreatment before adhesive application may have various advantages such as decreasing the possibility of secondary caries lesion formation by enhancing dentin remineralization and diminishing dentin solubility¹⁷ and reducing dentin hypersensitivity due to the dentinal tubule occlusion after its application.^{23,27} TiF4 solution is also effective in reducing enamel demineralization.⁴⁷ A twofold mechanism has been mentioned for these beneficial effects. The first one is increased fluoride uptake by enamel due to the titanium interaction of the TiF4 solution with the low pH with enamel surface.²³ The second one is pertained to the action of the titanium. Because of the low pH of the TiF4 solution (around 1.2), titanium links the oxygen of the group phosphate resulting in the formation of the titanium dioxide glaze-like layer on the surface acting as a physical barrier against penetration of the acids released by the bacteria, which is attributed to the decreased softening of the tooth structure surface.^{24,25,48} Moreover, titanium may act as a calcium substitution in the apatite lattice.^{23,49} In a self-etch adhesive system, such as that of the silorane-based composite, titanium tetrafluoride may react with large amounts of calcium and phosphate available in the smear layer resulting in the formation of insoluble products, a massive structure, and a modified smear layer resistant to both ethylenediaminetetraacetic acid and sodium hypochlorite treatments.²⁶ On the contrary, Devabhaktuni and Manjunath²⁹ showed that dentin pretreatment with TiF4 before or after application of acid phosphoric did not influence the bond strength to dentin when using a three-step etch and rinse adhesive system. Also, Bridi et al³¹ found that dentin pretreatment with TiF4 did not affect the microtensile bond strength of two-step or one-step self-etching adhesives. They also observed that adhesive penetration did not differ between dentin pretreated with TiF4 and dentin not pretreated with TiF4.³¹ According to the results of the present study, TiF4 solution did not affect the microleakage scores of the nanofilled and silorane-based composites at the enamel

margin. However, it may have some beneficial long-term effects on sealing efficiency of the composite resins that need to be investigated in the future studies. In contrast, at the dentin margins, for the silorane-based composite restorations, TiF4 solution pretreatment resulted in significantly lower microleakage. However, the similar result was not observed for Filtek Z350 XT.

In the present study, TiF4 solution (at a pH of 1.4 and a concentration of 2.5%) was actively applied with a brush on the surface for 60 seconds before application of the silorane system self-etch primer. According to Wiegand et al,³⁰ this mode of application can induce the formation of an acid-stable glaze-like layer. Also, in the current study, the smear layer was not removed in groups restored with silorane-based composite. It is known that the presence of smear layer results in the production of a massive structure after TiF4 application.²⁶ Moreover, due to the unstable pH of the TiF4 solution,⁵⁰ only freshly prepared TiF4 solution was applied on the tooth structure in this study. Despite probable adverse side effects of the acidic TiF4 solution (pH 1–2) on oral soft tissue, it is known that this acidic solution is the appropriate vehicle for dentin pretreatment.¹⁸ Also, in a previous study, it was concluded that TiF4 at pH of 1.2 reduced calcium loss significantly, whereas TiF4 solution at 3.5 failed to show the same effect.³⁰ Moreover, accurate adjustment of the pH and concentration of the TiF4 solution is important because the protective effect of this solution decreased with reducing the concentration or increasing the pH of the TiF4 solution.⁵¹ However, Vieira et al⁵² showed inhibitory effect for erosion progression using lower concentration of TiF4 solutions (especially 0.5%). With this in mind, it is recommended to investigate the effect of different concentrations of TiF4 solution on the enamel and dentin substrates.

The differences in the results of the various *in vitro* studies may be attributed to the differences in the experimental design regarding the size and design of the cavities, type of materials tested, tooth age, the size and type of the teeth used, thermocycling, type of dental tissue, and composite placement technique and polymerization.⁵³

Microleakage evaluation was used to assess the sealing efficiency of the resin composites in this study. This method is mentioned as the most common method of evaluation of the sealing ability of a restorative material.⁵⁴ Also, the microleakage test is used to evaluate the influence of contraction stress at the adhesive interface.⁵⁵ As no gold standard is considered for microleakage evaluations, dye penetration testing using 0.5% basic-fuchsin solution for 24 hours was performed in this study. Revealing a minor aspect of adhesion by microleakage studies is an important limitation of them.⁵⁶ Moreover, in the present study, after longitudinally sectioning through the restoration, the

microleakage scores were evaluated as two-dimensional (2D). This method may represent one limitation, in that three-dimensional (3D) evaluation may result in more accurate and real microleakage values. However, the 2D method is easier and cheaper than other techniques. Another considerable factor is the probable detrimental effect of masticatory forces on long-term durability and adaptation of composite restorations that has been discussed in a previous study.⁵⁷ Also, increasing leakage values by the combination of mechanical loading and thermal cycling has been shown.⁵⁸ Thus, more studies assessing the effects of thermal cycling, mechanical loading, and storage on microleakage of the material used in this study are necessary.

Clinical relevance of the differences found between experimental groups of the present study is yet to be investigated by long-term clinical trials.

CONCLUSION

Within the limitations of this study, the following conclusions can be obtained:

- At the enamel margins, microleakage score of the silorane-based composite (with or without the application of the TiF4) was more than that of the nanofilled composite. No significant differences were observed between the other groups. Also, TiF4 solution pretreatment did not affect the microleakage.
- At the dentin margins, for the silorane-based composite restorations, TiF4 solution pretreatment resulted in significantly lower microleakage. However, the similar result was not observed for Filtek Z350 XT. Also, no significant difference was observed between microleakage scores of Filtek P90 and Filtek Z350 XT with or without TiF4 pretreatment.

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