



## Gingival Microleakage of Class V Composite Restorations with Fiber Inserts

Walaa Ahmed, Wafa El-Badrawy, Gajanan Kulkarni, Anuradha Prakki, Omar El-Mowafy

### ABSTRACT

**Aim:** This study investigated the effect of different fiber inserts (glass and polyethylene), bonding agents, and resin composites on the gingival margin microleakage of class V composite restorations.

**Materials and methods:** Sixty premolars were sterilized and mounted in acrylic resin bases. Class V cavities were prepared buccally and lingually, 1 mm below the cemento-enamel junction, comprising 12 groups ( $n = 10$ ). In the experimental groups fiber inserts were cut and placed at the gingival seat, while the control groups had no inserts. Combinations of two composite materials, Filtek-Z250 and Filtek-LS (3M-ESPE), and four bonding agents, Clearfil SE bond (Kuraray) (C), Scotch Bond Multipurpose (3M-ESPE) (SB), Prime and Bond NT (Dentsply) (PB), and Filtek-LS (3M-ESPE) (LS) were used. Restorations were incrementally inserted and polymerized for 40s. Specimens were then stored in distilled water for 7 days and thermocycled for 500 cycles. Teeth surfaces were sealed with nail polish except for 1 mm around restoration margins and immersed in 2% red procion dye. Teeth were then sectioned buccolingually and dye penetration was assessed with five-point scale. Data were statistically-analyzed by Kruskal-Wallis, ANOVA and Tukey's tests ( $\alpha = 5\%$ ).

**Results:** Mean microleakage scores varied from 0.40 (Groups C, C with polyethylene, LS, LS with polyethylene) to 1.50 (SB).

**Conclusion:** Different bonding agents led to differences in microleakage scores where C and LS showed significantly lower microleakage than PB. SB had highest mean microleakage score, however, incorporation of fibers resulted in significant reduction in microleakage.

**Clinical significance:** Class V resin composite restorations bonded with a total-etch adhesive had a significant reduction in mean microleakage scores when glass or polyethylene fibers were placed at the gingival cavo-surface margin. In contrast, for two self-etch adhesive systems, the incorporation of fibers had no significant effect on mean microleakage scores.

**Keywords:** Laboratory research, Microleakage, Composite restoration, Fiber inserts, Class V.

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### INTRODUCTION

Microleakage is one of the most frequently encountered drawbacks with composite restorations, especially at the gingival margins when located apical to the cemento-enamel junction (CEJ). Previous studies reported greater gingival rather than occlusal microleakage,<sup>1</sup> as an important predisposing factor to clinical failure of restorations through development of recurrent caries. Some determinants that may affect microleakage include integrity of enamel and dentin, acid-etching time, bonding system, cavity design and C-factor.<sup>2</sup> However, polymerization shrinkage remains a major challenge to the longevity of resin composite restorations. Typically, resin composites undergo a volumetric shrinkage of about 2% upon polymerization.<sup>3</sup>

Adverse clinical consequences of the polymerization shrinkage include the potential for debonding. Marginal discrepancy, staining, postoperative sensitivity, microleakage and recurrent caries are likely consequences of such debonding.<sup>4</sup> Methods to reduce polymerization shrinkage have focused on either chemical modifications to the composite material formulations, or modified clinical procedures such as different composite insertion techniques, the application of flowable resin liner, new adhesive systems, modified light curing procedures and the incorporation of fiber inserts.<sup>1,5</sup>

The predominant organic matrix used in commercial dental composites consists of bisphenolglycidyl dimethacrylate (Bis-GMA) diluted with triethylene glycol dimethacrylate (TEGDMA).<sup>6</sup> Recently, silorane low shrinking commercial dental composites have been introduced to the market. Silorane is the product of reaction of siloxanes and oxiranes molecules.<sup>7</sup> It is considered to

have combined the two key advantages of the individual components, which are low polymerization shrinkage and increased hydrophobicity. The silorane system used in Filtek-LS (3M-ESPE) has been shown to provide lower shrinkage (<1%) than typical dimethacrylate-based resins.<sup>8</sup> This is most likely because siloranes are polymerized by a cationic epoxide reaction in contrast to methacrylates, which cross-link via free radicals. They 'open' their molecular structures with local volumetric expansion, which may partly or totally compensate for volumetric shrinkage.<sup>9,10</sup>

Incorporation of fiber inserts in composite restorations involves placing the fiber in the cavity near the gingival cavo-surface margin within the composite restoration. The use of fiber inserts, both glass or polyethylene has been shown to significantly reduce gingival microleakage in class II composite restorations with gingival margins in dentin, irrespective of the bonding agent used.<sup>5</sup> In addition, substantial improvements in mechanical properties were achieved when resin composites were reinforced with fiber inserts that resulted in restorations with higher flexural strength, toughness and elastic modulus, rendering them more resistant to deformation and fracture.<sup>11</sup>

The purpose of this study was to investigate the effect of glass or polyethylene fiber inserts on the microleakage of class V resin composite restorations with gingival margins on root surface. This was achieved through determining dye penetration along tooth/restoration interface when four different bonding systems and two different resin composites (Filtek-Z250 and Filtek-LS) were used.

## MATERIALS AND METHODS

Sixty sound human premolars were selected for this study. Teeth were sterilized with Gamma irradiation<sup>12</sup> for 4h (0.3 kGy/h, Gammacell 220, Atomic Energy Ltd, Mississauga, Canada), cleaned with periodontal scalers and curettes and stored in distilled water in a refrigerator. The teeth with poorly-distinguished CEJ were excluded from the study and replaced with other teeth.

Apical foramina of the teeth were sealed with glass ionomer cement (Fuji I, GC Corporation, Tokyo, Japan). Two layers of nail varnish were applied on the root surface, except for 3 mm below the CEJ to prevent dye penetration. Roots of the teeth were mounted in chemically-cured acrylic resin bases (Ivolen, Ivoclar Vivadent, Liechtenstein, Germany), up to 3 mm below to the CEJ. Standard class V cavities were prepared on both buccal and lingual surfaces of each tooth (120 cavities) using #257 tungsten carbide burs (SS White, Great White Series, Lakewood, NJ, USA) in an air turbine handpiece with profuse water cooling. The preparation dimensions were 3 mm long (mesiodistally) × 1.5 mm deep × 2 mm wide (occlusogingivally), with the

gingival margins extending about 1 mm below the CEJ on the root surface. All line angles were prepared rounded and a new bur was used for every three cavity preparations.

Table 1 shows details of all materials used. Prepared teeth were randomly divided into 12 groups (120 cavity preparations; n = 10) according to the assigned type of resin composite/bonding system/fiber insert (Table 2). Restorations without fiber inserts were used as control. The restorations were placed in two increments using the free-hand technique with each increment being polymerized for 40 s (Demi-LED, Kerr Corp, US, 1100 to 1200 mW/cm<sup>2</sup>, 44 J/cm<sup>2</sup>). The first increment of composite was applied diagonally from the inner gingivoaxial lineangle to the occlusal cavosurface margin. The second increment filled up the remainder of the cavity. The glass fiber inserts (0.9 mm thick), where applicable, were cut into pieces 3 mm long and positioned into the restoration at the gingival seat after polymerization of the first increment and before the application of the second increment. The polyethylene fiber inserts (1.5 mm thick) were similarly cut. They were then impregnated with the assigned bonding agent and gently dried with gauze before insertion as previously described. Restorations were finished with #12-blade multifluted carbide burs with a water-cooled high-speed hand-piece and polished with aluminum oxide points (Jiffy Points, Ultradent). The same operator (WA) performed all cavity preparations and restorations.

## Microleakage Evaluation

Following the restorative procedures, specimens were stored in distilled water at 37°C for seven days. They were then subjected to an artificial thermal aging challenge according to the ISO recommendations.<sup>13-15</sup> Briefly, 500 thermocycles were performed alternating immersion of the specimens in water baths with temperatures of 5°C and 55°C using a dwell time of 60 s. Teeth surfaces were then sealed with two layers of nail polish to prevent dye penetration, except for 1 mm around the restoration margins. Teeth were then immersed in 2% procion red dye solution (Pararosanilin, Imperial Chemical Industries, London, England) for 24 hours at 37°C.<sup>16</sup> After removal from the dye solution, the teeth were rinsed with tap water for 5 minutes. They were then sectioned buccolingually at the middle third of the crown by means of a diamond saw in a precision water-cooled slicing machine (Isomet, Buehler, Lake Buff, IL, USA). Produced sections were scanned into 300 × 300 dpi digital images (ScanMaker 9800XL, Microtech, Inc, CA, USA). The section with the deepest dye penetration was selected to represent the specimen. Dye penetrations at the gingival margins were assessed by two independent examiners to

determine the extent of microleakage according to a five-point scale as follows. In case of disagreement, a third examiner evaluated and resolved the dispute:

- 0 = No dye penetration
- 1 = Dye penetration limited to the outer half of gingival floor
- 2 = Dye penetration extended along the whole gingival floor

- 3 = Dye penetration extended along gingival floor and up to half of the axial wall
- 4 = Dye penetration extended along the gingival floor and entire axial wall.

### Scanning Electron Microscopy (SEM)

Two specimens of each group were randomly selected for SEM examination. They were mounted on a 12 mm metal

**Table 1:** Details of materials used in the study

Material	Brand	Manufacturer	Type of material and composition	Lot #
Composites	Filtek-Z250	3M ESPE, Seefeld, Germany	Bis-GMA, UDMA, Bis-EMA. Inorganic filler: zirconia/silica (60% v/v). Particle size 0.01-3.5 µm.	N142099
	Filtek-LS	3M ESPE, Seefeld, Germany	Silorane-resin; camphorquinone, iodonium salt, electron donor, stabilizers and pigments. Inorganic fillers: quartz/yttrium fluoride (55% v/v). Particle size 0.1-2 µm.	N130168
Bonding agents	Clearfil SE-Bond	Kuraray Medical Inc, Sakazu, Kurashiki, Okayama, Japan	Two step self-etch; Primer: MDP, HEMA, hydrophilic dimethacrylates, N, N-diethanol p-toluidine, CQ, water.	061520
			Bond: MDP, HEMA, Bis-GMA, hydrophobic dimethacrylates, silanated colloidal silica, N, N-diethanol p-toluidine, CQ	
	Prime and Bond NT	Dentsply	One step self-primer; Etchant: Caulk 34% tooth-conditioner gel Adhesive: di-and trimethacrylate resins, functionalized amorphous silica, PENTA, photoinitiators, cetylaminehydrofluoride acetone	100401
	Scotchbond Multi-Purpose	3M ESPE, St Paul, MN, USA	Etchant: 35 % phosphoric acid. Primer: Vitrebond copolymer and HEMA Water. Bond: Bis-GMA, HEMA, and initiators.	N151092
	Filtek-LS	3M ESPE, Seefeld, Germany	Self-etch primer: phosphorylated methacrylates, vitrebond copolymer, Bis-GMA, HEMA-Water, ethanol, silane-treated silica filler, initiators, and stabilizers. Bond: hydrophobic dimethacrylate, phosphorylated methacrylates, TEGDMA, silane-treated silica filler, initiators and stabilizers.	N128155
Fiber inserts	Glass fiber	EverStick, Stick Tech Ltd, Turku, Finland	E-glass, PMMA, Bis-GMA, resin-preimpregnated continuous unidirectional FRC	5018
	Polyethylene fiber	Ribbon-THM, Seattle, WA, USA	Ultra high strength polyethylene (UHSPE) fibers; Leno woven spectra fibers	9578

Abbreviation: Bis-GMA (bisphenol a diglycidyl ether dimethacrylate), Bis-EMA (bisphenol a polyethylene glycol diether-dimethacrylate), FRC (Fiber reinforced composite), HEMA (hydroxyethyl methacrylate), MDP (methacryloyloxydecyl dihydrogen phosphate), PENTA, dipentaerythritol penta-acrylate monophosphate. TEGDMA (tetraethyleneglycol dimethacrylate), and UDMA (urethane dimethacrylate)

**Table 2:** Experimental and control groups with the type of composite, bonding agents and fiber inserts that were used

Groups	Composites	Bonding agents	Inserts
C	Filtek Z-250	Clearfil SE-Bond	no inserts
C-G			glass fiber
C-P			Polyethylene fiber
PB			no inserts
PB-G	Filtek Z-250	Prime and Bond NT	glass fiber
PB-P			Polyethylene fiber
SB			no inserts
SB-G			glass fiber
SB-P	Filtek Z-250	Scotch Bond Multi-Purpose	Polyethylene fiber
LS			no inserts
LS-G			glass fiber
LS-P			Polyethylene fiber
	Filtek-LS	Filtek-LS	



SEM stub using cyanoacrylate adhesive and gold sputter coated (EMS-76M; Earnest F). Qualitative evaluations were performed at 100× magnification.

### Statistical Analyses

The effect of different inserts, composites, and bonding agents on mean microleakage values was analyzed by Kruskal-Wallis test. Kruskal-Wallis was also used to analyze data within groups of the same bonding system. Data on the effect of different bonding agents on microleakage was shown to have normal distribution (Kolmogorov-Smirnov test) and was tested by ANOVA followed by Tukey's test. The level of significance was set at 0.05. The statistical software used was SPSS 20, which is a widely respected general statistical software package from IBM.

### RESULTS

Means and standard deviations of the microleakage scores for all groups are presented in Table 3. The statistical analysis showed that type of insert (glass fiber or polyethylene fiber) had no significant difference on the microleakage values ( $p = 0.25$ ). Likewise, the different composites (Filtek-Z250 or Filtek-LS) also did not statistically influence the microleakage values ( $p = 0.16$ ). On the other hand, different bonding agents (Clearfil SE-Bond, Prime and Bond NT, Scotchbond Multi-Purpose, Filtek-LS) had significant effects on the microleakage scores ( $p = 0.02$ ). When analyzing data within each bonding group, the SB bonding system showed statistical difference between the control and the groups with inserts ( $p = 0.014$ ). SE and LS resulted in lowest mean microleakage scores. In contrast SB and PB control groups had higher mean microleakage scores, however, incorporation of inserts significantly reduced microleakage scores with SB groups only.

### DISCUSSION

Results of the current study showed no strong evidence that glass or polyethylene fiber inserts placed at the gingival margin reduce the microleakage of class V composite restorations, except for the groups that used SB system. In contrast, El-Mowafy and others<sup>5</sup> and Basavanna and others<sup>17</sup> found significant reductions in microleakage when glass or polyethylene fibers were placed on the gingival margin of class II composite restorations. There are different reasons to explain the variability in the outcomes of those studies compared to the present study. In the case of class II restoration studies<sup>5,17</sup> a matrix was placed around the teeth and polymerization light was applied from the occlusal surface. Inserts may have assisted the composite increment in resisting pull-away from margins toward the light polymerization preventing gap formation. Light attenuation as it travels through the length of the proximal box might play a secondary role.<sup>18</sup> In contrast, in the present study (class V) the polymerization light was applied directly to the composite increment without a matrix.

Another factor that may have contributed to the difference in results between class II and V studies is the variability in the cavity size. In a previous study<sup>5</sup> the class II slot cavities were performed in molar teeth, and measured 3 mm wide × 1.5 mm in axial depth, with the gingival floor located at least 1 mm below the CEJ on the root surface. Although a class II cavity presents less C-factor than class V, characteristics such as cavity depth, number of resin layers, lower light intensity that reaches class II gingival floor due to irradiation been performed from coronal direction may account to a higher leakage.<sup>18</sup> Consequently, these cavities were markedly more benefitted by the inserts. It has been stated that reinforcing effect of glass fibers was more effective than that of polyethylene fibers due to difficulty in obtaining good adhesion between polyethylene and resin matrix.<sup>19</sup> In the present study, no significant

**Table 3:** Counts, means and standard deviations (SD) of microleakage scores for the evaluated groups

Groups	Counts of microleakage scores					Mean (SD)
	0	1	2	3	4	
C	6	4	0	0	0	0.40 (0.516) <sup>a</sup>
C-G	8	1	0	0	1	0.50 (1.269) <sup>a</sup>
C-P	6	4	0	0	0	0.40 (0.516) <sup>a</sup>
PB	2	7	0	1	0	1.00 (0.816) <sup>b</sup>
PB-G	3	3	3	1	0	1.20 (1.033) <sup>b</sup>
PB-P	5	3	2	0	0	0.70 (0.823) <sup>b</sup>
SB	3	3	2	0	2	1.50 (1.509) <sup>c</sup>
SB-G	9	1	0	0	0	0.10 (0.316) <sup>d</sup>
SB-P	4	4	2	0	0	0.80 (0.789) <sup>d</sup>
LS	6	4	0	0	0	0.40 (0.516) <sup>e</sup>
LS-G	7	1	0	1	1	0.80 (1.476) <sup>e</sup>
LS-P	7	2	1	0	0	0.40 (0.699) <sup>e</sup>

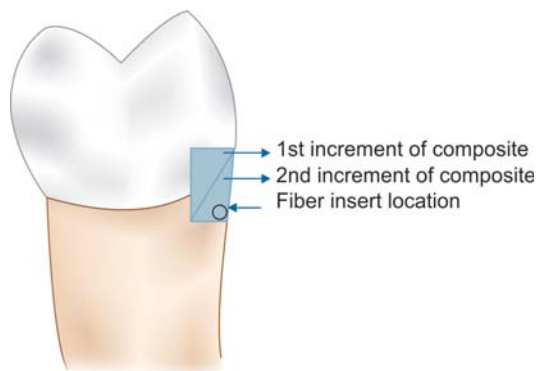
Same superscript letters indicate no statistical difference among data within the same bonding used ( $\alpha = 0.05$ )

difference was found in microleakage scores between both inserts, which is in accordance to Basavanna et al.<sup>17</sup> This is probably due to the preimpregnated, salinized and plasma treated polyethylene system used in this study which may have enhanced bonding with resin.

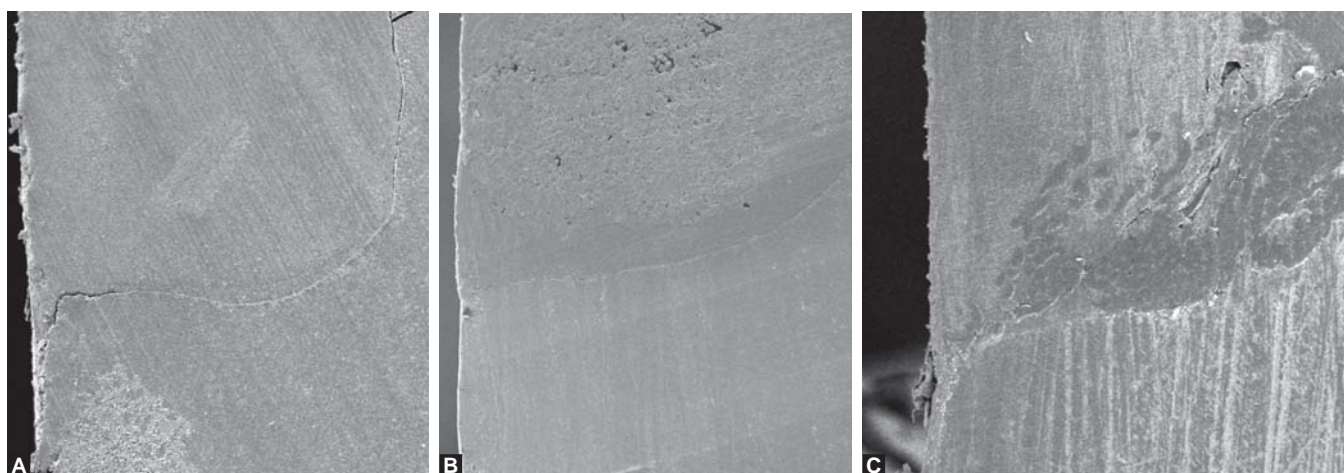
In an attempt to reduce shrinkage stresses in the current study, two increments of the resin composite were applied diagonally to minimize the effects of C-factor. The inserts were positioned into the restoration at the gingival seat after polymerization of the first increment and before the application of the second increment (Fig. 1). The rationale for using such technique is that minimal shrinkage stress would occur within first increment due to reduced C-factor, which permits the resin to flow during the polymerization. As the second increment was added, it compensated for shrinkage of the first increment.<sup>20</sup> Filtek-Z250 and Filtek-LS did not statistically influence the microleakage values in the current study. The composites manufacturer (3M-ESPE) has reported volumetric polymerization shrinkage of 2% and <1% for Filtek-Z250 and Filtek-LS,

respectively. Although less marginal leakage with Filtek-LS was expected,<sup>8</sup> it is difficult to make direct comparison between both resins as the results may have been influenced by the different bonding agents.

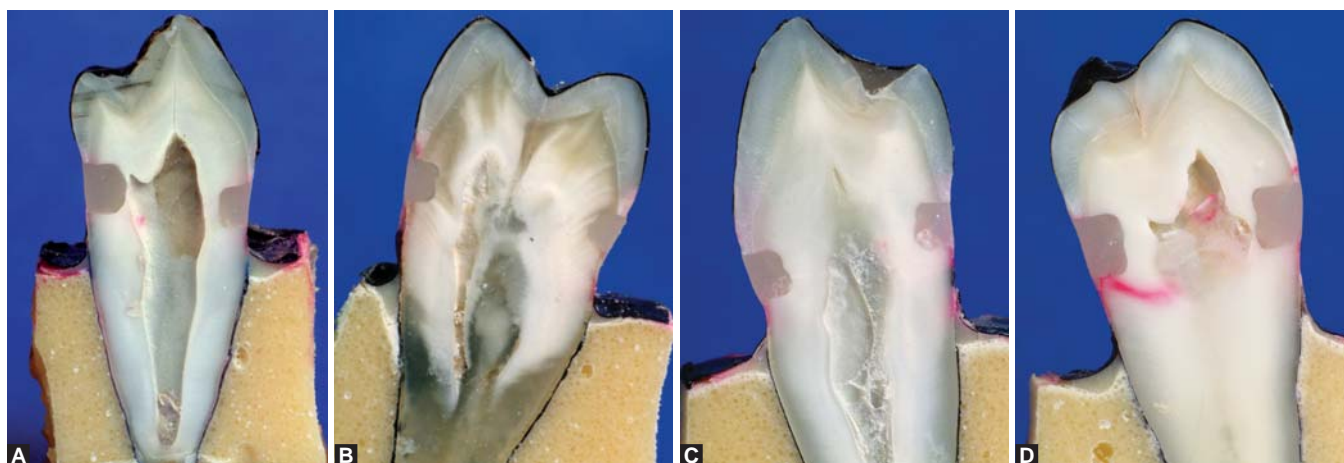
The four adhesives used in this study belong to three categories (Figs 2 and 3). C and LS are two-step self-etch



**Fig. 1:** Representative diagram of buccolingual cross-section for class V composite with fiber insert



**Figs 2A to C:** Representative micrographs of sectioned class V restorations (100x): (A) Z250 + Prime and Bond NT; (B) Z250 + Prime and Bond NT + glass insert; (C) Z250 + Clearfil SE-Bond + polyethylene insert



**Figs 3A to D:** Representative digital images of sectioned class V restorations with the different bonding agents: (A) Clearfil SE-Bond; (B) Filtek-LS; (C) Prime and Bond NT + polyethylene insert; (D) scotch bond multipurpose + glass insert

adhesives while SB is a three-step total-etch adhesive and P is a two-step total-etch adhesive. Generally, C and LS, the self-etch adhesive systems, resulted in lower microleakage scores compared to PB and SB, the total etch systems. When analyzing data within the SB groups, the control showed significantly higher microleakage value compared to the ones that received inserts (Table 3). This suggests that inserts would enhance the marginal seal quality of a bonding system with higher microleakage. Bonding and microleakage to dentin structure has been reported to be significantly affected by acid-etching. Collagen fibers in the dentin substrate may collapse after phosphoric acid etching as in PB and SB and may result in an impaired interfacial bond.<sup>21</sup> Additionally, increase in microleakage values have been shown to occur due to possible failure of the primer to infiltrate the entire demineralized zone, resulting in gap formation.<sup>22,23</sup> Conversely, using milder acidic adhesives to remove the superficial loosely bonded dentin smear layer, as in C and LS, might somewhat have enhanced adhesion and therefore reduced the marginal microleakage.<sup>24</sup> Moreover, the self-etch bonding formulations include the 'Molecular Dispersion Technology,' enabling a two phase liquid (hydrophilic and hydrophobic components) to reach a homogenous state at the molecular level, reportedly resulting in reduction and loss of water droplets at the adhesive interface with subsequent superior bond.<sup>25</sup> Also, the molecular structure of 10-methacryloyloxydecyl dihydrogen phosphate adhesive monomer allows for decalcification and penetration into the tooth structure, creating a chemical bond to calcium.<sup>26</sup>

It has been stated that when the mechanism for debonding at cavity walls is taken into account, microleakage is considered to be correlated to bond strength.<sup>27,28</sup> It is however, important to also recognize that microleakage values and therefore the clinical performance of resin restorations is also greatly influenced by other factors such as cavity size and shape, bonding procedures, restorative procedures and techniques, and the restorative materials.<sup>29</sup>

## CONCLUSION

Within the limitations of this study, the following conclusions were drawn:

1. The two self-etching bonding systems (C and LS) resulted in the lowest mean microleakage scores. For both of them the incorporation of inserts did not significantly reduce mean microleakage scores ( $p > 0.05$ ).
2. SB had the highest mean microleakage scores, which were significantly reduced by incorporation of either type of inserts ( $p < 0.05$ ).

## CLINICAL SIGNIFICANCE

Class V resin composite restorations bonded with a total-etch adhesive had a significant reduction in mean microleakage scores when glass or polyethylene fibers were placed at the gingival cavo-surface margin. In contrast, for two self-etch adhesive systems, the incorporation of fibers had no significant effect on mean microleakage scores.

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