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RESEARCH ARTICLE

COMPARATIVE EVALUATION OF GINGIVAL MICRO LEAKAGE OF CLASS II COMPOSITE RESIN RESTORATIONS WITH DIFFERENT FIBER INSERTS – AN IN VITRO STUDY

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ABSTRACT

Purpose: This investigation was carried out to evaluate the effect of glass and polyethylene fiber inserts on the micro leakage of Class II composite restorations with gingival margins on root surfaces.
Materials and method: Standard MO or DO cavities were prepared in 60 extracted premolars. The teeth were randomly divided into three groups (n=20). Control group Group 1: Filtek P 60 composite resin - Incremental technique with *No fiber inserts*; Group 2: *Ribbond Triaxial Polyethylene fibers* + Filtek P 60 composite resin - Incremental technique; Group 3: *EverStick Ortho Glass fibers*+ Filtek P 60 composite resin - Incremental technique. All the teeth were thermo cycled for 500cycles (5°C and 55°C) and then immersed in methylene blue solution for 24 hours. The teeth were sectioned longitudinally and observed under a stereomicroscope. Micro leakage at gingival margin was recorded according to dye penetration scores. Statistical analysis was performed by using one-way ANOVA and Mann Whitney U tests ($p<0.05$).
Results and conclusion: Samples with fiber inserts showed significantly less micro leakage compared to the control. Also, glass fibers were superior to polyethylene fibers, though the difference was non-significant None of the samples showed complete elimination of microleakage.

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INTRODUCTION

Resin-based composite materials have made significant improvements in their properties, however, one of their major disadvantage is microleakage at the tooth resin interface (Pearson *et al*., 1999). Factors causing this are polymerization shrinkage, physical characteristics of resin composites (filler loading, modulus of elasticity, water sorption, coefficient of thermal expansion), C-factor of the cavity, placement technique, light curing methods, occlusion components, finishing and polishing effects etc (Baratieri, 2001). It is proved that etched and bonded enamel produces a more consistent seal compared to dentin because of its complex structure (Perdigao *et al*., 1969).

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Efforts to decrease the gingival microleakage of class II composite resin restorations include techniques for light polymerization aimed at reducing the amount of composite volumetric shrinkage (Oberholzer *et al*., 2005), reducing the ratio of bonded to unbonded restoration surfaces (C-factor) (Feilzer *et al*., 1987), use of different dentin adhesive systems (self- etch or total etch) (Kanca, 1999), following strategic incremental placement techniques (Puckett *et al*., 1992), use of resin modified glass ionomer cements (Gupta *et al*., 2002) and flowable composites (Attar *et al*., 2004). However, none of the above mentioned techniques, aimed to reduce gingival microleakage of cervically deep class II cavities, produced gap free margins. Glass fiber and polyethylene fiber inserts have been developed to increase the filler-resin ratio of the composite resin restorations. These inserts act as "Megafillers" to reduce the overall polymerization shrinkage of the composite resin restoration (Donly, 1989).

The fibers possess adequate flexure modulus and flexural strength to function successfully in the mouth (Valittu, 1999). This in vitro study was carried out to evaluate the effect of glass and polyethylene fiber inserts on the microleakage of Class II composite restorations with gingival margins on root surfaces.

MATERIALS AND METHODS

Sixty freshly extracted human maxillary premolars free of caries, attrition, abrasion, erosion, restorations and craze lines were selected for the study. The teeth were cleaned and stored in distilled water for 1 week. Class II slot cavity preparations were made on the proximal (mesial / distal) surface of each sample using a FG-169L taper fissure carbide bur (S.S. White, Germany). All line angles were rounded. The gingival margin of the preparation was extended 1 mm below the cemento-enamel junction on the root surface. Cavity dimensions were 3 mm wide buccolingually, 4.5-5.5 mm in height and the axial wall 1.5 mm deep, all measured with a periodontal probe. (Fig 1.a) The enamel cavosurface margin was beveled (45^0, 0.5 mm) with a TF 11 diamond point (Mani). The teeth were randomly divided into three groups of 20 samples each, based on the restorative technique used. (Table 1)

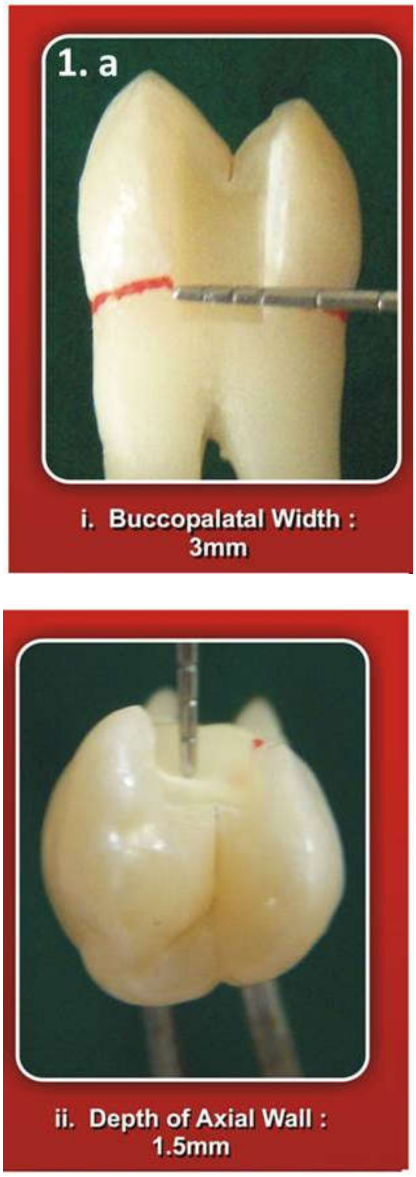

Figure 1.a. Cavity location and dimensions

Figure 1.b: polyethylene fibers

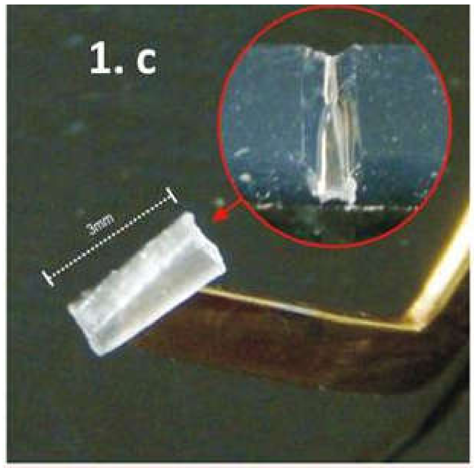

Figure 1.c. Glass fibers

Figure 1.d. Restored tooth coated with nail varnish

A universal metal matrix band/retainer (Tofflemire) was placed and cavity was cleaned with water spray and was air-dried for five seconds. One drop each of liquid A and B self etching bonding agent Adper SE plus (3M ESPE, St Paul, MN, USA) were dispensed into separate wells.Liquid A was applied to the entire bonding area to obtain a continuous pink layer.

A second brush tip was used to scrub Liquid B into the entire wetted surface of bonding area. The pink colour disappeared quickly indicating that the etching components had been activated. The bonding area was thoroughly air dried for 10 seconds and a second coat of Liquid B was applied to the entire bonding area. The adhesive layer was light cured for 10 seconds with OptiLite LD Max (Gnatus) LED curing unit. For samples of Group II, polyethylene fiber (Ribbond Triaxial, Ribbond Inc., Seattle, Washington, USA) was cut into pieces, each measuring 3 mm in length and 1 mm in width and wetted with few drops of bonding adhesive (Prime & Bond - Dentsply De Trey Gmbh, UK).(fig. 1.b)For samples of Group III, 3 mm long pieces of resin pre-impregnated glass fiber EverStick Ortho (StickTech Ltd, Turku, Finland), 0.75 mm in diameter each along with its silicone bedding were cut using sharp scissors. (fig 1.c). Less than 1 mm thick amount of resin composite Filtek P-60 Shade B2 (3M ESPE, St Paul, MN, USA) was first placed on the gingival floor.Then, 3 mm piece of respective fiber insert was placed onto the uncured composite increment and condensed through it to adapt it against the gingival floor and displace the composite to fill into the corners of the box.

It was light polymerized for 40 seconds from the occlusal surface using OptiLite LD Max (Gnatus) LED curing unit in soft start mode. Remaining cavity was restored using diagonal incremental technique. Restorations were then finished and polished with Shofu Super-Snap (ShofuInc, Kyoto, Japan) aluminum oxide discs of decreasing abrasiveness. The teeth were stored in distilled water at room temperature for two weeks. The restored teeth were thermocycled for 500 cycles at temperatures of 5^0C ± 2^0C and 55^0C ± 2^0C with a dwell time of 10 seconds in each water bath and a transfer time of 10 seconds between each bath.The samples were blotted dry and the root apices were sealed with sticky wax.The teeth were coated with two layers of nail varnish (Lakme) except for an area approximately 1 mm around the gingival margin of the restorations. (Fig 1.d)

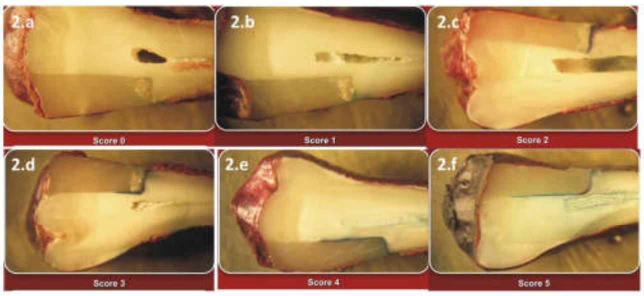

Figure 2:Dye penetration scores
2.a: score 0- No dye penetration
2.b: score 1- Dye penetration up to the outer half of the gingival floor
2.c: score 2- Dye penetration up to the inner half of the gingival floor
2.d: score 3- Dye penetration extending through the gingival floor up to 1/3 of the axial wall
2.e: score 4- Dye penetration extending through the gingival floor up to 2/3 of the axial wall
2.f: score 5- Dye penetration extending through the gingival floor up to the DEJ level

Figure 2. Dye penetration scores

The teeth were then immersed in 2% methylene blue dye for 24 hours at room temperature, removed and thoroughly rinsed.They were then sectioned with a thin diamond disc (DFS, Germany) through the center of the restoration such that two sections were obtained from each tooth. The degree of dye penetration in each tooth was assessed under 20X magnification with a stereomicroscope (Olympus SZ40). Based on the ordinal ranking system (Ferrari *et al*., 1994), the degree of dye leakage was determined as shown in Fig 2. Dye penetration at the restoration-tooth interface was scored for cervical margins only and data was tabulated. To determine statistically significant differences in leakage at cervical margin among three tested groups, non-parametric data were analyzed using Kruskal-Wallis one-way Analysis of Variance test and an intergroup comparison was performed by Mann Whitney-U test.

RESULTS

The mean microleakage scores indicate lowest mean leakage score of 0.40 ± 0.6806for Group III followed by Group II (1.00 ± 1.0260) and Group I (2.95 ± 0.9445). (Table 2)Kruskal-Wallis one-way ANOVA indicated significant differences between groups ($p < 0.0001$). Intergroup comparison with Mann-Whitney U test showed that Group II and Group III showed significantly less dye leakage than Group I ($p \leq 0.001$). Group III (mean rank – 19.42) showed slightly better results than Group II (mean rank – 23.55) with no statistical significance (Table 3)

Table 1. Description of groups

Group I	Adper SE Plus adhesive + Filtek P 60 composite resin - Incremental technique with *No fiber inserts*
Group II	Adper SE Plus adhesive + *RibbondTriaxial Polyethylene fibers* + Filtek P 60 composite resin - Incremental technique
Group III	Adper SE Plus adhesive + *EverStick Ortho Glass fibers* + Filtek P 60 composite resin - Incremental technique

DISCUSSION

This study showed that significantly less microleakage was noted at the resin- dentin interface with the use of fiber inserts (group II and III) as compared to those with no inserts (Group I). The Leno Weave Ultra High Modulus (LWUHM) polyethylene fiber used in this study has a high modulus of elasticity and lower flexural modulus. Eskitascioglu*et al*[13] reported the elastic modulus of 23.6 Gpa of a polyethylene fiber in combination with adhesive resin has a modifying effect on the interfacial stresses developed along the etched enamel-resin boundary. Glass fibers used here have also demonstrated their ability to withstand tensile stress and to stop crack propagation in composite material. The internal stress patterns of the restorative material can change by the application of a glass fiber layer (Valittu, 1999). The Self-etch adhesive system used in this study is a simplification of enamel-dentin bonding procedures with demineralization, priming and resin concentrated into one material. The colour-change indicator gives visual confirmation of coverage as well as proper etch activation. The technique provides for a solvent-free, hydrophobic overcoat with low technique sensitivity and more consistent performance. Brandt *et al*. (2006) demonstrated that as far as microleakage is concerned, self-etching bonding agents (two-step self-etch, 6th generation) could be clinically acceptable alternatives to the clinically proven Scotchbond Multipurpose. Also, Prati C *et al*[15]demonstrated that self-etching systems (6th Generation), despite their limited thickness of resin-infiltrated dentin-layer produced the highest immediate bond strengths. This study used aging by thermocycling to simulate degradation of bond over a period of time in oral cavity. Fiber inserts have less coefficient of thermal expansion as compared

Table 2. Microleakage scores and statistical analysis on application of kruskal- wallis test

Score group	0	1	2	3	4	5	Mean score	Standard deviation	Mean rank	Chi square value	P value	Result
Group I	01	02	04	10	02	01	2.95	0.9445	48.53			
Group II	10	05	04	01	00	00	1.00	1.0260	23.55			Significant
Group III	13	04	03	00	00	00	0.40	0.6806	19.42	35.100	0.000	as p<o.o5

Table 3. Results of Intergroup comparison using Mann- Whitney U test

Intergroup comparison	Mann Whitney U	P value	Result
Group I and Group II	27.000	0.000	Significant
Group I and Group III	12.500	0.000	Significant
Group II and Group III	166.00	0.302	Non significant

to composite resin matrix, hence they decrease the overall coefficient of thermal expansion of these restorations (Rossomando, 1995). Teeth were assessed for microleakage by dye penetration method using 2% methylene blue. This method is simple, economic, quick and is hence most employed (Alani, 1997). The results of this in vitro study indicate that none of the groups tested completely eliminated microleakage at cementum (dentin) margins. Both polyethylene fibers and glass fibers significantly decreased the gingival microleakage of class II composite resin restorations as compared to control group ($p<0.05$). If the total amount of composite material used to restore a Class II cavity could be reduced, the overall amount of polymerization shrinkage would be proportionately decreased owing to the presence of less organic matrix. Xu *et al*. (2003) stated that, when fiber inserts are placed in Class II composite restorations, they replace the part of the composite increment at this location, which results in a decrease in the overall volumetric polymerization contraction of the composite. Also, the fibers assist the initial increment of the composite in resisting pull-away from the margins toward the light source. Basavanna *et al*. (2012) reported that the reinforcing effect of glass fibers was more effective than polyethylene fibers due to difficulty in obtaining good adhesion between the polyethylene fibers and resin matrix. Hamza *et al*. (2004) used silane coupling agent and plasma treatment to increase the degree of adhesion of the polyethylene fibers to the resin and found no significant difference between the reinforcing effects of glass and polyethylene fibers. Both studies showed no statistically significant difference between the glass and polyethylene fibers ($p>0.05$). In the current study glass fibers used were pre-impregnated with polymethyl methacrylate and Bisphenol-A glycidyldimethacrylate (Bis-GMA), while polyethylene fibers were wetted with adhesive resin before insertion.

Less microleakage scores showed by glass fiber inserts as compared to polyethylene fiber inserts can be explained by the fact that glass fibers transmit light to the gingival increment of composite resin during curing thus increasing its hardness, physical properties and durability. Also, glass fibers were pre-impregnated with Bis-GMA (by manufacturer) which may produce better bond strength with composite resin as compared to polyethylene fibers which were wetted with adhesive resin (chairside). Fiber inserts modify other properties of composites too. Soderholm, (1984) showed that an inverse linear relationship exists between the volume fraction of filler in composite resins and its coefficient of thermal expansion. Thus, more the filler loading in composite resins, such as by inserting "Megafillers" like glass fibers or polyethylene fibers, more is the decrease in coefficient of thermal expansion of reinforced composite restorations.

Conclusion

Polyethylene fiber inserts and glass fiber inserts significantly reduced the gingival microleakage of Class II composite resin restorations but could not completely eliminate microleakage. Also, glass fiber inserts showed superior results as compared to polyethylene fiber inserts.

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