DOI: 10.18410/jebmh/2015/670

ORIGINAL ARTICLE

EFFECT OF PLACEMENT TECHNIQUES, FLOWABLE COMPOSITE, LINER AND FIBRE INSERTS ON MARGINAL MICROLEAKAGE OF CLASS II COMPOSITE RESTORATIONS

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HOW TO CITE THIS ARTICLE:
Anupriya Bugalia, Yujvender, Neha Bramta, Jitin Kharbanda, Mansi Atri, Gaurav Kharbanda. "Effect of Placement Techniques, Flowable Composite, Liner and Fibre Inserts on Marginal Microleakage of Class II Composite Restorations". Journal of Evidence based Medicine and Healthcare; Volume 2, Issue 32, August 10, 2015; Page: 4779-4787, DOI: 10.18410/jebmh/2015/670

ABSTRACT: AIM: The aim of this study was to evaluate effect of placement techniques, flow able composite, and fiber inserts in marginal adaptation of class II composite restorations. **MATERIALS AND METHODS:** 120 class II box cavities were prepared on both mesial and distal surfaces of extracted human molars. The prepared teeth were randomly assigned to 6 groups: 1) bulk insertion. (Single increment), 2) Oblique incremental placement technique, 3) Centripetal incremental placement technique. 4) Split horizontal incremental placement technique. 5) flow able composite as gingival increment 6) ribbond fiber insert in gingival increment. The preparations were restored with a total etch adhesive (Adper Single Bond, 3M ESPE) and nano composite (Z350, 3M ESPE). Specimens were isolated with nail varnish except for a 2-mm-wide rim around the restoration and thermocycled (1,000 thermal cycles, 5°C/55°C; 30-second dwell time). The specimens were immersed in a solution of 2% methylene blue dye for 24 hours. The teeth were sectioned longitudinally, observed under stereomicroscope and evaluated for microleakage using an ordinal scale of 0 to 4. The microleakage scores obtained from gingival walls were analyzed with Kruskal-Wallis and Mann Whitney nonparametric tests. **RESULTS:** Among all placement techniques split incremental technique showed least microleakage scores. The group that used flowable composite liner did not show significant reduction in microleakage and group with fiber inserts showed significant decrease in microleakage scores. **CONCLUSION:** None of the techniques eliminated marginal microleakage in class II composite restorations. However, the split incremental technique and group with fiber inserts showed significantly lower microleakage at gingival margin when compared to other groups.
KEYWORDS: Polymerisation shrinkage, Composite resin, Microleakage, Ribbond.

INTRODUCTION: Composite resin has been widely used to restore posterior teeth for decades.[1] The use of this material has been continually increasing because of ability to bond to dental structure, its high esthetics and conservative preparation.[2]

Despite improvements of the adhesion to dental structure, direct adhesive restorations for posterior teeth are still technique sensitive.[3] One of the major disadvantage of composite resin is polymerization shrinkage. Shrinkage occurs as resin polymerize, because monomer cross link to form polymer network that occupy smaller volume than monomer. During placement of composite resin, shrinkage stress may disrupt the continuity of bonded walls, producing interfacial gaps, which can lead to microleakage, marginal discolouration, secondary caries and postoperative sensitivity.[4]

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For this reason one must address techniques that relieve stress. Various studies include methods for following strategic incremental placement techniques in order to reduce residual stresses at tooth restoration interface.[5] The most common technique described to reduce stress is the oblique incremental technique. Bichacho demonstrated another technique that constructed a thin composite proximal wall before filling the entire preparation, popularly known as centripetal technique.[6] Recently Hassan et al introduced split incremental technique, where each horizontal increment is split in two halves to reduce C factor, hence polymerisation shrinkage.[7]

Also flowable composite have been recommended as liner at gingival margins in proximal box of class II composite restoration to improve marginal integrity, due to its lower modulus of elasticity and better flow, with a hope of reducing microleakage and postoperative sensitivity. Flowable composite liner may also act as a flexible intermediate layer that helps to relieve stresses during polymerisation shrinkage of restorative resin.[8]

Recently fiber inserts such as ribbond have demonstrated their ability to withstand tensile stresses and stop crack propagation in composite.[9] It is said that when ribbond layer is applied the internal stress pattern of restoration changes. It reduces or eliminates the interfacial stress concentration at restoration/tooth interface, hence reducing the gap formation and microleakage.[10]

Thus the aim of this study to investigate the effect of ribbond fiber insert, application techniques (Bulk, Oblique, Centripetal, Split horizontal) and flowable composite as liner on the microleakage in posterior adhesive class II restorations.

METHODS AND MATERIALS:

Products	Type	Composition	Manufactures
Scotchbond etchant gel	Etchant	37% phosphoric acid	3M ESPE, St Paul, MN, USA
Adper single bond	Total etch bonding system	BisGMA, HEMA, dimethacrylates, ethanol, water	3M ESPE, St Paul, MN, USA
Filtek Z350	Nanocomposite	BIS-GMA, BIS-EMA UDMA with small amounts of TEGDMA. 20nm nanosilica filler	3M ESPE, St Paul, MN, USA
Filtek Z350 flow	Nanofilled flowable composite	BIS-GMA, BIS-EMA with of TEGDMA. 20 nm nanosilica filler	
Ribbond	Glass fiber	E-glass, Bis GMA and PMMA	Stick Tech, Turku Finland

Table 1: Manufacturers And Composition Of The Materials Utilized In The Study

60 sound human molar were collected, cleaned of calculus, soft tissue and debris and stored in distilled water. 120 standardized class II cavities were prepared at mesial and distal surface of each tooth with following dimensions -2.0mm occlusal extension, 3.0 mm bucco-gingival extension and 5mm occluso-cervical extension. The preparations were made with a no 245 carbide bur, under copious water coolant, in a high speed hand piece.

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A sectional metallic matrix (Palodent® Sectional Matrix System, Dentsply Caulk) was placed and adapted to cavosurface margins with green modeling impression compound for stabilization.

Bonding Procedure: The cavities were etched with Scotchbond Etchant (3M ESPE) for 15 seconds. Thoroughly washed with water for 15 seconds and blot dried. The dentin was kept moist. A fifth generation bonding agent Adper single bond (3M ESPE) was applied with applicator tip and light cured for 20 seconds. All specimens were restored with a nanocomposite resin Z350 (3M ESPE).

All the specimens were divided into 6 groups each containing ten teeth.

Restorative Procedure:

Group I: Bulk placement technique. A single layer of composite was applied to fill the preparation up to the cavosurface margin. The increment was cured for 120 seconds.

Group II: Oblique placement technique. The first increment was horizontally placed at cervical wall and light cured for 40 seconds. The second increment was obliquely placed contacting the buccal and axial walls and the previously cured increment and cured for 40 seconds. The third increment was obliquely placed, filling the preparation and light cured for 40 seconds.

Group III: Centripetal placement technique. A thin layer of composite, 0.5mm thick, was applied toward the metallic matrix contacting the cavosurface of the proximal box up to half of occlusal - cervical extension. A second layer was applied over the previous increment contacting cavosurface margin of the proximal box and forming marginal ridge. Both the composite increments were cured for 40 seconds each. The resulting class one cavity was restored in 2 horizontal increments, each increment being cured for 40 seconds.

Group IV: Split horizontal incremental technique. The marginal ridge was formed as in centripetal technique to form a class 1 cavity. Later first 2mm horizontal increment is placed. One diagonal cut was made in increment in order to split it into two triangular-shaped flat portions, which were cured for 40 seconds. In this way, each portion of the split-increment contacted half of the gingival wall and only two of the surrounding cavity walls during curing instead of opposing each other. The diagonal cut was filled completely with composite and light cured for 40 seconds from the occlusal direction. Similarly second horizontal increment was placed up to cavosurface margin and light cured.

Group V: Flowable group- a layer of flowable composite resin Filtek flow Z 350(3M ESPE) was applied as first gingival increment and cured for 40 seconds. Rest of cavity was restored with composite resin in two horizontal increments with each increment being cured for 40 seconds.

Group VI: Ribbond fiber group-A 1mm thick amount of resin composite was first placed on the gingival floor. Then a 2mm piece of fiber insert 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. Light polymerization followed for 40 seconds from occlusal cavity. Two other horizontal increments of composite were placed to fill the cavity and cured for 40 seconds each.

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Preparation for Microleakage Test: After the restoration was completed the metallic matrices were removed and specimens were stored in distilled water at 37°C for 24 hours. The restorations were finished and polished.

To evaluate microleakage, the teeth surface was isolated with 2 layers of finger nail varnish, except for 2mm around the restoration. The specimens were thermocycled for 1,000 cycles at 5-/+1°C and 55+/-1°C with 30 seconds dwell time. Then the specimens were immediately immersed in methylene blue dye for 24 hours.

After that nail polish was removed and specimens were sectioned through centre of restoration with diamond disc. The sections were polished and analyzed with a stereomicroscope at 10x magnification and scored for the degree of dye penentration along the cervical walls using the scores described below-

0 = No dye penetration.
1 = Dye penetration extending to one-third of cervical wall.
2 = Dye penetration extending to half of the cervical wall.
3 = Dye penetration into cervical wall.
4 = Dye penetration into the cervical wall and axial wall toward the pulp.

The scores obtained were statistically analysed by Kruskal - Wallis test. Later to find significant differences between different groups Mann-Whitney was carried out.

RESULTS:

Groups	Score 0	Score 1	Score 2	Score 3	Score 4
Gr-1-bulk	0	2	2	8	8
Gr-2-Oblique	0	4	8	6	2
Gr-3 Centripetal	0	7	8	4	1
Gr-4-Split incremental	4	7	6	2	1
Gr-5 Flowable composite liner	0	5	9	4	2
Gr-6-Ribbond fiber insert	4	7	8	1	0

Table 2: Microleakage scores

Group	Mean	Std. dev.	Median	Kruska-Wallis Chi-square	P-Value
Group I	3.10	0.79	3	50.933	<0.001
Group II	2.35	0.99	3		
Group III	1.70	0.92	2		
Group IV	0.80	0.77	1		
Group V	2.15	0.93	2		
Group VI	1.25	0.85	1		

Table 3: Statistical analysis of marginal microleakage at gingival margin

DOI: 10.18410/jebmh/2015/670

It was observed that there was a significant difference between the groups with respect to micro-leakage (P<0.001). Higher mean micro-leakage was found to be in Group I (Bulk) followed by Group II (Oblique), Group V (Flowable), Group III (Centripetal) and Group VI (Ribbond) respectively. Group IV (Split incremental) recorded the lowest mean micro-leakage.

In order to find out among which pair of groups there exist a significant difference, Mann-Whitney test was carried out and the results are given in table 3.

Group (I)	Group (II)	Mean difference	Z	P-Value
Group I	Group II	0.75	-2.342	0.019*
	Group III	1.40	-4.038	<0.001*
	Group IV	2.30	-5.246	<0.001*
	Group V	0.95	-3.064	0.002*
	Group VI	1.85	-4.821	<0.001*
Group II	Group III	0.65	-1.948	0.051
	Group IV	1.55	-4.188	<0.001*
	Group V	0.20	-0.736	0.462
	Group VI	1.10	-3.189	0.001*
Group III	Group IV	0.90	-2.942	0.003*
	Group V	-0.45	-1.287	0.198
	Group VI	0.45	-1.540	0.124
Group IV	Group V	-1.35	-3.999	<0.001*
	Group VI	-0.45	-1.664	0.096
Group V	Group VI	0.90	-2.781	0.005*

Table 4

*denotes significant difference.

It was observed that there was a significant difference between Group I (Bulk) & Group II (Oblique) (P<0.05), Group I (Bulk) & Group III (Centripetal) (P<0.001), Group I (Bulk) & Group IV (Split incremental) (P<0.001), Group I (Bulk) & Group V (Flowable) (P<0.01) and also between Group I (Bulk) & Group VI (Ribbond) (P<0.001) with respect to micro-leakage.

The difference between Group II(Oblique) & Group III(Centripetal) as well as Group II (Oblique) and Group V (Flowable) with respect to micro-leakage was not found to be statistically significant (P>0.05).

Statistically significant difference was found between Group II (Oblique) & Group IV (Split incremental) (P<0.001), Group II (Oblique) & Group VI (Ribbond) (P<0.01).

Between Group III (Centripetal) & Group IV (split incremental), statistically significant difference is observed with respect to micro-leakage (P<0.01). No statistically significant difference was found between Group III (centripetal) & Group V (flowable) as well as Group III (Centripetal) & Group VI (Ribbond) (P>0.05).

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Statistically significant difference was observed between Group IV (Split incremental) & Group V (Flowable) ($P<0.001$) but no significant difference was observed between Group IV (Split incremental) & Group VI (Ribbond) ($P>0.05$).

Between Group V (Flowable) & Group VI (Ribbond), statistically significant difference was observed ($P<0.01$) with respect to micro leakage scores

DISCUSSION: The use of direct placement composite resin for the restoration of posterior teeth has become commonplace because of increasing patient demand for more aesthetic restorations. However there are a number of well recognized problems associated with these materials and polymerization shrinkage appears currently to be the most significant problem.[11] Polymerization shrinkage stress have the potential to initiate failure at composite tooth interface, producing interfacial gaps, which can lead to microleakage, marginal discolouration and secondary caries.[12]

Several approaches to counteract polymerization shrinkage stress have been advocated over a period of time most common being, placement of composite in increments. The result of present study demonstrates that incremental placement technique definitely reduces microleakage when compared to bulk technique. The reduction in amount of composite, the diminution of polymerization shrinkage, and the enlargement of the free surface area in relation to the volume are of great importance in this context.[13]

Among other incremental techniques followed in present study, the centripetal placement technique performed better than oblique incremental technique**.** Meridith et al stated that because the amount of composite required to build up the proximal wall is minimal compared to that for the oblique technique, it is supposed to achieve a better marginal adaptation.[14] The results of present study is in agreement with the findings of Szep et al. They stated that even if there were a gap at the cervical wall after the proximal wall was complete, the following horizontal increment would be able to flow and fill the space[15]

Split horizontal incremental technique showed least microleakage scores. With this echnique, polymerization shrinkage stress was relieved by splitting the continuous large horizontal increment in the proximal and occlusal cavities into smaller triangular flat portions prior to photocuring. This split would reduce the C-factor from a ratio of 5 to a ratio of 1 for proximal portions.[16] The smaller increment size, along with the lower C-factor, would relieve most of the shrinkage stresses by means of flow of the free surfaces, rather than at the bonded interfaces, which otherwise would increase cuspal deformation.[17]

Khamis et al stated that the sequence for filling the two diagonal cuts with composite would prevent the split-increment portions of composite resin from contacting two opposing cavity walls simultaneously; as a result, the negative effects of polymerization shrinkage stresses on the cavity walls and adhesive interfaces would be minimized.[16]

To reduce microleakage flowable composites were recommended by the manufacturers. Flowable composites used as liner under high filled resins in posterior restorations have shown to improve the adaptation of composites and effectively achieve clinically acceptable results Low elastic modulous of flowable composites provides flexibility for the bonded restorations.[18] Lining might lead to more equal distribution of stresses over the adhesive interface and acts as stress breaker.[19] Though present study showed lower microleakage scores in flowable group than bulk, yet other incremental techniques fared better than flowable. The result is in accordance with the study of Milena Cardeno et al who quoted that lesser amount of filler content in flowable composite can result in more shrinkage.[20]

Xu and others[21] stated that, when fiber inserts are placed in class II composite restorations, they increase the quality of marginal zone in two ways. First, the fibres 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 fibres assist the initial increment of the composite in resisting pull-away from the margin toward the light source. The fibres 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 and thus improves marginal adaptation[21].In current study the ribbond fiber group showed least microleakage scores comparable with split incremental technique.

El-Mowafy and others found same results and their study also supported the findings of current study.[22]

The dye penetration method is frequently used in order to measure microleakage. All teeth were immersed in 2% methylene blue dye for 24 hours at 37°C. Methlene blue dye provides a simple, relatively inexpensive quantative and comparable method of evaluation of leakage of resin composite.[23]

Other than the placement techniques the restorative material used also affects the polymerization shrinkage in restorations. In current study universal nanocomposite Filtek Z350 was used for restoration, which utilizes novel technique in nanotechnology to create a composite that displays the polish and polish retention of a microfill while maintaining the strength and wear properties of a modern hybrid. As the filler particle diameter in nanocomposite was only 5 μm i.e., about half the wavelength of the activating light and the light scattering was increased, thereby decreasing the degree of conversion and consequently polymerization shrinkage.[24]

The results of present study suggest that fiber inserts, flowable composite and even placing composite by split incremental or centripetal technique, reduced microleakage to some extent. Still producing restorations free of gaps,is a challenge for clinicians and researchers.

Marginal integrity and microleakage in vitro experiments are currently being performed to evaluate the effects of the different placement techniques on the quality of the margins in composite restorations.[25] While performing in vitro microleakage investigations, obtaining conclusive information can be problematic, since vast differences in research protocols are reported in the dental literature; leakage patterns are highly complicated and irregular; and, one section of the tooth cannot be relied on for drawing a conclusion. So further studies are required before definite conclusions can be formulated.

CONCLUSION: Under the conditions of current in vitro study;

Microleakage significantly decreased in groups where composites were applied by the Incremental technique compared to bulk technique.

Flowable composite resin did not show significant improvement in microleakage as compared to oblique incremental technique.

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Use of centripetal technique reduces microleakage considerably in comparison to oblique technique.

Split horizontal incremental technique performed better than all techniques other than fiber group and the group with fiber inserts showed best results i. e. least microleakage.

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Date of Submission: 26/07/2015.
Date of Peer Review: 27/07/2015.
Date of Acceptance: 01/08/2015.
Date of Publishing: 07/08/2015.