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ORIGINAL RESEARCH

Effect of Four Different Placement Techniques on Marginal Microleakage in Class II Composite Restorations: An *in vitro* Study

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ABSTRACT

Background and objectives: This study was undertaken to evaluate the effect of different placement techniques (bulk, oblique incremental, centripetal and split horizontal) on marginal microleakage in class II composite restoration.

Method: Standardized class II preparations were made in 40 caries-free extracted molars and randomly assigned to four groups (n = 10): (1) Bulk technique (2) oblique incremental insertion technique,(3) centripetal incremental insertion technique and (4) split horizontal incremental insertion. The teeth were restored with a total-etch adhesive and nanocomposite resin.The specimens were immersed in a solution of 2% methylene blue for 24 hours, and subsequently evaluated for leakage. The microleakage scores (0 to 4) obtained from the occlusal and cervical walls were analyzed with Kruskal-Wallis and Mann-Whitney tests ($p < 0.05$).

Results: Microleakage scores indicated that incremental technique was better than bulk for composite placement and among incremental techniques split incremental technique showed best results.

Conclusion: Incremental placement technique showed lower microleakage compared to bulk, and lower microleakage was seen at occlusal margin compared to gingival margin. Split horizontal incremental technique showed the least microleakage scores among incremental techniques

Keywords: Composite, Polymerization shrinkage, Microleakage, Incremental technique.

INTRODUCTION

Advancements in science and dental materials have led to a paradigm shift in the way teeth are restored today. The increasing demand for tooth colored restorations, cosmetic dental procedures, conservation of tooth structure together with dramatic advances in the field of adhesive technology has led to widespread placement of direct composite restorations.[1] However, resin composite materials undergo volumetric polymerization contraction of at least 2% which may result in gap formation as the composite pulls away from cavity margins during polymerization.[2] Such gaps can result in passage of salivary fluid along the tooth restoration interface, resulting in microleakage.[3]

Microleakage is one of the most frequently encountered problems in posterior composite restorations, especially at the gingival margins. Recurrent caries at the gingival margin of class II composite restoration with subsequent failure of restoration has been most often attributed to such microleakage.[4] Efforts have been made to develop methods to decrease this problem with class II composite restorations. This includes, techniques for light polymerization aimed at reducing the amount of composite volumetric shrinkage, reducing the ratio of bonded to unbonded restoration surfaces (C-factor) and following strategic incremental placement techniques to reduce residual stress at tooth restoration interface.[2,5]

Several incremental techniques have been proposed over a decade to restore class II cavities, such as horizontal incremental, oblique incremental, centripetal incremental technique. The idea of oblique technique as proposed by Lutz et al was to increase adhesive free surface, allowing better flow of resin, hence reduction of polymerization shrinkage.[6] Bichacho demonstrated centripetal incremental technique, which involved construction of a thin composite proximal wall before filling the entire preparation with increments ensuring better adaptation of composite to cavity walls.[7] Recently a new technique, the split horizontal incremental technique, has been proposed as modification of centripetal incremental technique, in which after building the proximal wall, the horizontal increments placed to fill the class I cavity so formed, are split to further reduce the C-factor, hence microleakge.[8]

Although a lot of research has been done on various placement techniques as stated above, not much information is available on the effect of split horizontal incremental technique on marginal microleakage of class II composite restoration. Thus, the aim of this study was to compare marginal microleakage in posterior adhesive class II restoration placed with bulk, oblique, centripetal and split horizontal incremental techniques ,at the gingival and the occlusal margins.

MATERIALS AND METHODS

Forty sound human molar were collected, cleaned of calculus, soft tissue and debris and stored in distilled water. Eighty standardized class II cavities were prepared at mesial and distal surface of each tooth with following dimensions —2.0 mm occlusal extension, 3.0 mm buccogingival extension and 5 mm occlusocervical extension. The preparations were made with a no. 245 carbide bur under copious water coolant in a high speed handpiece (Table 1).

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) and divided into six groups.

Restorative Procedure

Group I—Bulk placement technique (Fig. 1): 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 (Fig. 2): The first increment was horizontally placed at cervical wall. The second increment was obliquely placed contacting the buccal and axial walls and the previously cured increment. The third increment was obliquely placed, filling the preparation. All increments were light-cured for 40 seconds each.

Group III—Centripetal placement technique (Fig. 3): A thin layer of composite, 0.5 mm thick, was applied toward the metallic matrix contacting the cavosurface of the proximal box upto half of occlusal-cervical extension. A second layer was applied over the previous increment contacting cavosurface

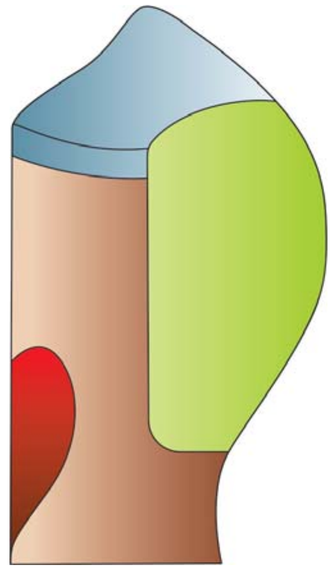


Fig. 1: Bulk placement technique

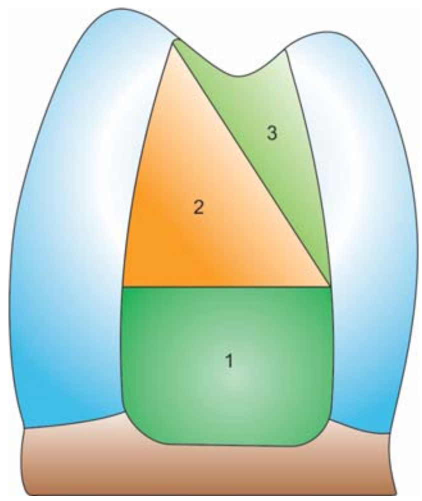


Fig. 2: Oblique placement technique

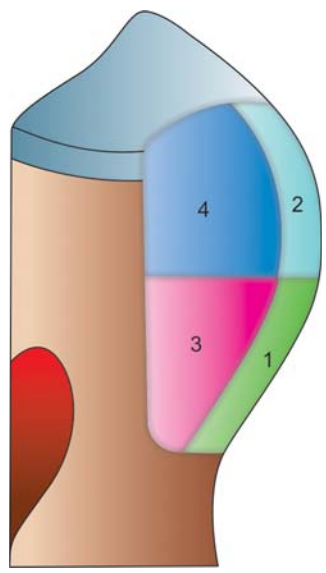


Fig. 3: Centripetal placement technique

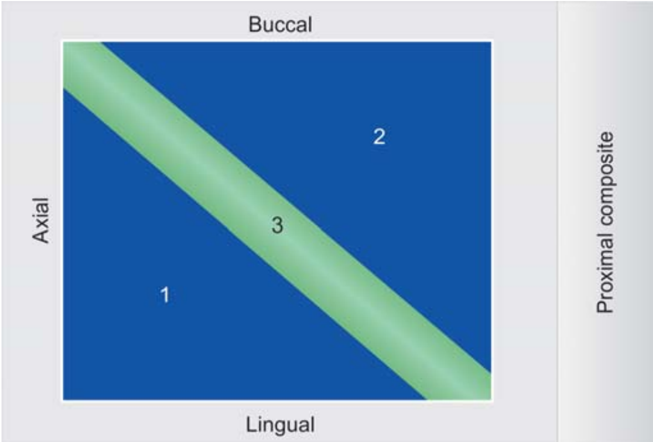


Fig. 4: Split horizontal incremental technique

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 two horizontal increments, each increment being cured for 40 seconds.

Group IV—Split horizontal incremental technique (Fig. 4): The marginal ridge was formed as in centripetal technique to form a class I cavity. Later first 2 mm horizontal increment is placed. One diagonal cut was made in increment 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 till cavosurface margin and light-cured.

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 were isolated with two layers of finger nail varnish, except for 2 mm 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 center of restoration with diamond disk. The sections were polished and analyzed with a stereomicroscope at 10× magnification. And scored for the degree of dye penetration along the occlusal and cervical walls using the scores described below:

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

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

RESULTS

It was observed that there was a significant difference between the groups with respect to microleakage both at occlusal margin and gingival margin ($p < 0.001$) (Table 2).

At occlusal margin, higher mean microleakage was found to be in group I (bulk) followed by group II (oblique) and group III (centripetal) respectively. Group IV (split incremental) recorded the lowest mean microleakage (Table 3).

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 4.

There was a significant difference between group I (bulk) and group II (oblique) ($p < 0.05$), group I (bulk) and group III (centripetal) ($p < 0.001$); and also between group I (bulk) and group IV (split incremental) ($p < 0.001$). While the difference between group II (oblique) and group III (centripetal) was not found to be statistically significant ($p > 0.05$), but the difference between group II (oblique) and group IV (split incremental) was found to be statistically significant ($p < 0.001$). However, between group III (centripetal) and group IV (split incremental), the difference was statistically significant ($p < 0.01$) (Table 5).

On analyzing the results with respect to microleakage at gingival margin as shown in Tables 3 and 6, statistically significant difference was observed between the groups tested. Higher mean microleakage was found to be in group I (bulk) followed by group II (oblique) and group III (centripetal) respectively. Group IV (split incremental) recorded the lowest mean microleakage.

Even with respect to microleakage at gingival margins Mann-Whitney test was carried out to analyze the intergroup variations and the results are tabulated (Table 7).

DISCUSSION

Polymerization shrinkage has been the major drawback of composite restorations, causing debonding of the restoration from the cavity wall.[9] The amount of shrinkage stress depends on the elastic compliance of the bonded preparation walls and the viscoelastic properties of the restorative material.[10] Since shrinkage is unavoidable, notwithstanding the bond strengths, the primary aim should be to relieve the stress.[11] Incremental placement of composite,[12] use of more flexible liners and

Table 1: Manufacturers and composition of the materials utilized in the study

Products	Type	Composition	Manufacturers
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. 20 nm nanosilica filler	3M ESPE, St Paul, MN, USA

Table 2: Microleakage scores at occlusal margin

Groups	Score 0	Score 1	Score 2	Score 3	Score 4
Group I	0	0	5	8	7
Group II	0	5	5	8	2
Group III	2	6	8	4	0
Group IV	8	8	8	4	0

Table 3: Microleakage analysis at occlusal margin

Groups	Mean	Std dev	Median	Kruskal-Wallis Chi-square	p-value
Group I	3.10	0.79	3.0		
Group II	2.35	0.99	2.5	39.221	< 0.001
Group III	1.70	0.92	2.0		
Group IV	0.80	0.77	1.0		

Table 4: Statistical analysis of microleakage scores among all groups at occlusal margin

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 II	Group III	0.65	–1.948	0.051
	Group IV	1.55	–4.188	< 0.001*
Group III	Group IV	0.90	–2.942	0.003*

*significant difference

Table 5: Microleakage scores at gingival margin

Groups	Score 0	Score 1	Score 2	Score 3	Score 4
Group I	0	2	2	8	8
Group II	0	4	8	6	2
Group III	0	7	8	4	1
Group IV	4	7	6	2	1

Table 6: Microleakage analysis at gingival margin

Groups	Mean	Std dev	Median	Kruskal-Wallis Chi-square	p-value
Group I	3.10	0.97	3		
Group II	2.30	0.92	2	25.923	< 0.001
Group III	1.95	0.89	2		
Group IV	0.30	0.92	1		

Table 7: Statistical analysis of microleakage scores among all groups at gingival margin

Group (i)	Group (ii)	Mean difference	Z	p-value
Group I	Group II	0.80	–2.590	0.010*
	Group III	1.15	–3.385	0.001*
	Group IV	1.80	–4.380	< 0.001*
Group II	Group III	0.35	–1.226	0.220
	Group IV	1.00	–2.987	0.003*
Group III	Group IV	0.65	–2.052	0.040*

*significant difference

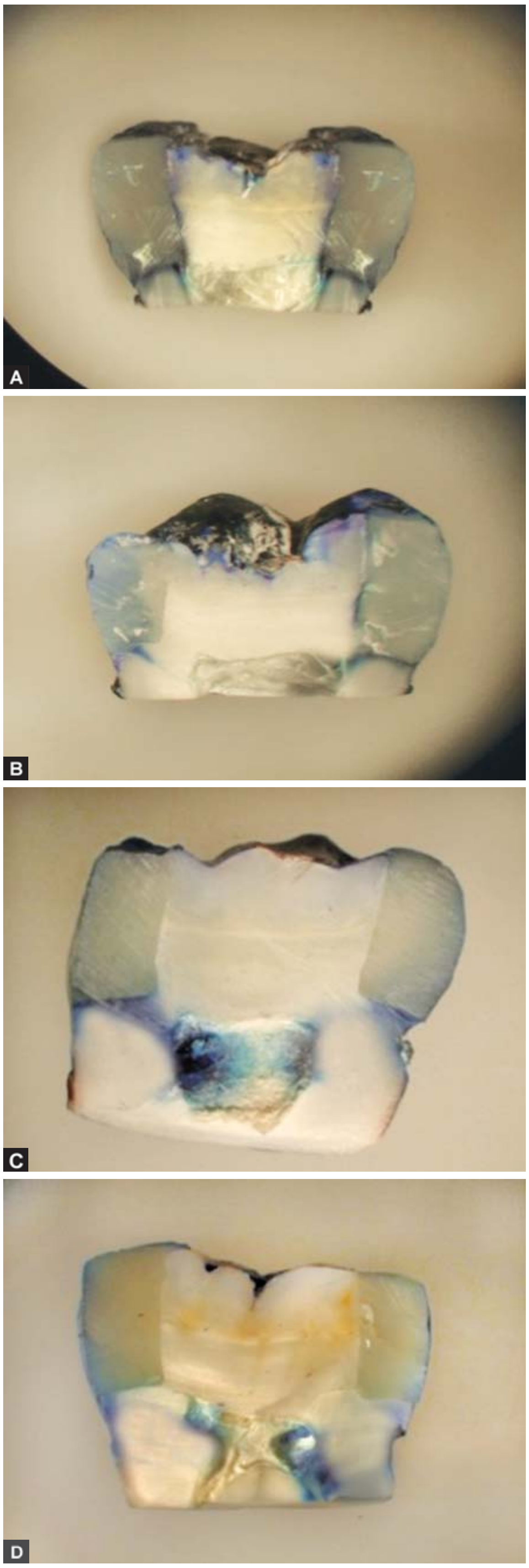
bases,[13] and modulation of curing[14] have been suggested as techniques for polymerization shrinkage stress relief (Figs 5A to D).

While going through the results of our study, we found that microleakage scores were lower at occlusal margins when compared to gingival margins in all groups. One factor that leads to this outcome is higher inorganic content in enamel, on account of which acid-etching creates microporosities, allowing better penetration of adhesive system, thus forming strong micromechanical bond with composite resin.[15] Gingival margin is frequently placed apical to cementoenamel junction making bonding more difficult because of heterogeneous nature of tissue. Consequently, the ability to achieve an effective seal at gingival margin although crucial is difficult to achieve.

Studies by Sillias Duarte, Lawrence W Stockhon, Sussan T Tang also confirmed the findings of present study.[16]

It was also observed that all the incremental techniques showed decrease in microleakage in comparison to bulk placement techniques. Among the incremental techniques, split technique showed least microleakage scores. This technique minimizes stresses by reducing the C-factor.[1] In a study by Hassan et al, it was stated that split horizontal placement technique makes it possible to relieve the polymerization shrinkage stresses generated at the adhesive interface, resulting in an improved marginal seal.[8]

On comparing oblique layering technique with centripetal technique the latter proved to be better in terms of microleakage scores at occlusal margin. Oblique technique showed significant microleakage despite reduction in C-factor. In this technique, during restorative procedures cusp tend to move due to polymerization shrinkage, and these cuspal movements can be in same direction, opposite or nonexistent. Thus, flexure of cusps



Figs 5A to D: Dye penetration along occlusal and gingival margin among all groups: (A) group 1, (B) group 2, (C) group 3, (D) group 4

reduces the ratio V/A (V–preparation volume, A–area of cavity wall), thus, reducing the amount of composite to be inserted into preparation. The increase in polymerization stress might produce a marginal gap if the polymerization stress surpasses the bond strengths.[1] Also, Sillias Duarte has stated that in centripetal technique there is better adaptation of composite resin to margins, which further leads to reduction of microleakage when compared to oblique technique.[1]

At the gingival margin, bulk placement technique showed greatest microleakage when compared to all other groups. Incremental restoration techniques actually lower C-factor to less than 1.0, because there is usually almost as much free surface as bonded surface in any single increment.[17] E Ozel also stated that incremental placement is the preferred restorative technique for posterior composite restorations as it results in better marginal adaptation.[18] Alster et al have shown that the stress relief in thin resin increments is proportional to the amount of resin porosity. The oxygen present in air void, incorporated in incremental technique, contributes to stress reduction.[19]

Centripetal technique achieved better marginal adaptation as the amount of composite required to build up the proximal wall was minimal compared to that for the oblique technique.[1] The results of present study is in agreement with the findings of Szep et al.[20] 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. Through the use of centripetal technique, the V/A ratio could be reduced. In oblique technique, in that the apical area of cavity will be filled completely with first layer of composite resin material. On the contrary, first layer of centripetal technique has no contact with the pulpoaxial walls, and thus has less tendency to contract towards this wall and away from cervical floor during polymerization.[20] The above said explanation could be responsible for reduced microleakage scores of centripetal technique as compared to oblique technique as seen in our study. However, the results were not statistically significant.

Split incremental technique showed the least microleakage scores. 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.[8]

Much of current literature focuses on elimination of microleakage, which is one of the major factors determining the long-term success of restorations. Within the limitations of this study, it can be inferred that placing composite in increments reduced microleakage as compared to bulk technique, and split incremental placement technique provided an adequate marginal adaptation, especially at the gingival margin. However, further *in vivo* and *in vitro* studies are required to determine the clinical validity of these techniques.

CONCLUSIONS

Under the conditions of the current *in vitro* study, it can be concluded that:

1. Microleakge was significantly lower at the occlusal margins in comparison to the gingival margins of class II composite restorations.

2. Microleakage was also significantly decreased in groups where composite resin was placed in increments when compared with bulk placement technique.
3. Among the incremental techniques, split horizontal incremental technique showed least microleakage followed by centripetal incremental technique and oblique placement technique at the occlusal margin of restorations.
4. At the gingival margin, there was no significant difference in microleakage between centripetal incremental and oblique placement techniques, and split horizontal incremental technique showed least microleakage.

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