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Evaluation of the Effect of Different Placement Techniques on Marginal Microleakage in Class II Composite Restoration: An Invitro Study

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ABSTRACT

Aim: To evaluate the effect of different placement techniques (bulk, horizontal, oblique, centripetal, split horizontal) on marginal microleakage in class II composite restoration.

Methodology: Fifty standardized class II cavities were prepared with following dimensions- 2mm occlusal extension, 3mm buccogingival extension and 5mm occlusocervical extension. The cavities were etched with 37% phosphoric acid and a bonding agent was applied with applicator tip and light cured for 20 sec. The prepared tooth is randomly divided into 5 groups of 10 teeth each and restored with Tetric N-Ceram bulk fill placed in different incremental techniques. **Group 1**: bulk fill has a single increment **Group 2**: horizontal placement **Group 3**: oblique placement **Group 4**: centripetal placement**Group 5**: split horizontal technique. The teeth surface were isolated with two layers of finger nail varnish, except for 2mm around the restoration. The specimens were immersed in methylene blue dye for 24 hrs. The specimens were sectioned through the center of restoration with diamond disc and analyzed with a stereomicroscope at 10x magnification. The microleakage scores (0 to 4) obtained from the occlusal and gingival margins were analyzed with Kruskal-Wallis Test followed by Dunn's post hoc test ($p<0,05$).

Results: Incremental placement techniques showed lower microleakage compared with bulk fill technique. Split horizontal technique showed the lowest microleakage compared all other groups and highest microleakage is seen in bulk fill technique.

Conclusion: Based on the results of the present study, none of the four placement techniques were found to be effective in eliminating marginal microleakage entirely in Class II restorations. Among the incremental techniques, split horizontal technique showed least microleakage followed by centripetal placement technique, horizontal technique, oblique placement technique.

I. INTRODUCTION

Resin composite is widely regarded as the material of choice for direct restorations in both anterior and posterior teeth, owing to its favourable clinical outcomes and long-term success rates as documented in the literature[1]. These materials offer numerous advantages, including ease of manipulation, superior physical and mechanical properties, excellent aesthetics due to the wide range of available shades and translucencies, biocompatibility, and reliable adhesion to enamel and dentin[2,3].

Clinical studies have reported excellent performance of resin composites, with annual failure rates ranging from 1% to 5% in anterior restorations and 1% to 3% in posterior restorations.

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Despite these encouraging results, one of the most commonly reported complications in posterior composite restorations is microleakage—particularly at the gingival margins. [4]

The primary challenges associated with direct composite restorations include polymerization shrinkage and associated shrinkage stress, incomplete polymerization (degree of conversion), and a limited depth of cure. These factors can compromise the adhesive interface and overall restoration longevity, leading to both adhesive and cohesive failures. [4]

Resin composites typically undergo volumetric shrinkage in the range of 2.6% to 7.1% during polymerization. This contraction can generate significant stress at the composite-tooth interface. If the composite material pulls away from the cavity walls due to this stress, marginal gaps may form. These gaps can be infiltrated by oral fluids and bacteria, resulting in microleakage. Consequences of microleakage include marginal discoloration, postoperative sensitivity, secondary caries, and even pulpal irritation or damage. [5]

Several factors influence polymerization shrinkage and stress development. These include the configuration factor (C-factor) of the cavity, filler content of the composite, degree of monomer conversion, elastic modulus of the material, water sorption, curing light characteristics, and the type of substrate being restored. [6]

Successful clinical outcomes largely rely on achieving proper polymerization and using effective placement techniques. To address related challenges, various strategies have been developed, such as incorporating flowable liners, adjusting curing protocols, and applying the composite in incremental layers. [7-10]

Among the available techniques, incremental layering is widely regarded as the gold standard for placing resin-based composite restorations. By applying the composite in small increments, each layer maintains minimal contact with the cavity walls during polymerization, which helps reduce shrinkage and stress. The polymerization shrinkage of each layer is effectively counteracted by the next, thereby reducing overall shrinkage stress and improving the restoration's marginal adaptation and longevity. [7,11-12]

So, the primary objective of this study was to evaluate the influence of various composite placement techniques—namely bulk fill, horizontal incremental, oblique incremental, centripetal, and split horizontal incremental on marginal microleakage in Class II composite restorations

II. METHODOLOGY

Fifty standardized class II cavities were prepared with following dimensions- 2mm occlusal extension, 3mm buccogingival extension and 5mm occlusocervical extension. The cavities were etched with 37% phosphoric acid and a bonding agent was applied with applicator tip and light cured for 20 sec. The prepared tooth is randomly divided into 5 groups of 10 teeth each and restored with Tetric N-Ceram bulk fill placed in different incremental techniques

Group 1: bulk fill has a single increment
Group 2: horizontal placement
Group 3: oblique placement
Group 4: centripetal placement
Group 5: split horizontal technique

The specimens are stored in distilled water at 37°C for 24 hrs. The teeth surface were isolated with two layers of finger nail varnish, except for 2mm around the restoration. The specimens were immersed in methylene blue dye for 24 hrs. After that, nail polish was removed and specimens were sectioned through the center of restoration with diamond disc and analyzed with a stereomicroscope at 10x magnificationThe degree of dye penetration along the occlusal and gingival walls using the scores given below

0= no dye penetration
1= dye penetration into enamel, dye penetration extending to 1/3rd of cervical wall
2= dye penetration into enamel-dentin 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 axial wall and axial wall towards the pulp

Restorative Procedure

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

Group II - The horizontal placement technique utilizes composite resin layers, each <2.0 mm thick and each layer is photocured.

Group III—Oblique placement technique: The oblique technique is accomplished by placing a series of wedge-shaped composite increments and photocuring each increment.

Group IV—Centripetal placement technique: An initial thin layer of composite, approximately 0.5 mm thick, was applied against the metallic matrix, extending along the cavosurface margin of the proximal box up to half the occluso-cervical height. A second increment was then placed over the first,

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contacting the remaining cavosurface margin and building up the marginal ridge. Each of these proximal increments was light-cured for 40 seconds. The resulting Class I cavity was subsequently restored using two horizontal composite increments, each cured for 40 seconds.

Group V—Split horizontal incremental technique: The marginal ridge was initially built using the centripetal technique, converting the preparation into a Class I cavity. A 2 mm thick horizontal composite increment was then placed. Before curing, a diagonal cut was made through this increment, dividing it into two triangular-shaped segments. These segments were light-cured individually for 40 seconds, allowing each to contact only half of the gingival floor and two adjacent cavity walls, thereby minimizing polymerization stress from opposing walls. The diagonal gap was subsequently filled with composite and cured for 40 seconds from the occlusal aspect. The second horizontal increment was then placed up to the cavosurface margin and light-cured in a similar manner.

Statistical analysis:

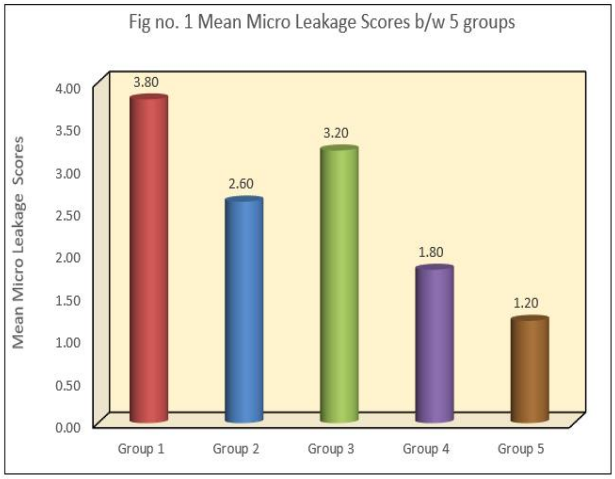
Kruskal Wallis Test followed by Dunn's post hoc test was used to compare the mean microleakage scores between 5 study groups. The level of significance was set at $p<0.05$.

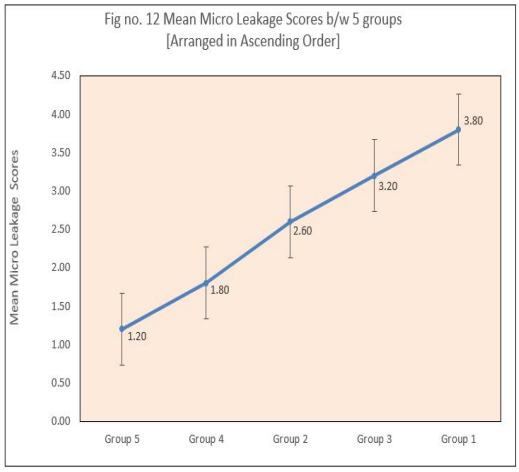
Comparison of mean Microleakage Scores b/w 5 groups using Kruskal Wallis Test

Groups	N	Mean	SD	Min	Max	P-Value
Group 1	10	3.80	0.42	3.0	4.0	<0.001*
Group 2	10	2.60	0.52	2.0	3.0	
Group 3	10	3.20	0.42	3.0	4.0	
Group 4	10	1.80	0.42	1.0	2.0	
Group 5	10	1.20	0.42	1.0	2.0	

III. RESULTS

It was observed that there was a significant difference between the groups with respect to microleakage. Group with incremental technique resulted in smaller microleakage compared to the bulk fill technique. Higher mean microleakage was found to be in bulk placement (group I) followed by oblique placement (group III) and horizontal placement(group II) and centripetal placement(group IV) respectively. Split horizontal placement technique (Group V) recorded the lowest mean microleakage.





IV. DISCUSSION

The present study evaluated the effect of different composite placement techniques on marginal microleakage in Class II restorations using Tetric N-Ceram Bulk Fill. The findings demonstrated that incremental techniques significantly reduced microleakage compared to the bulk fill technique, with the split horizontal technique exhibiting the least microleakage. In

contrast, the bulk fill technique showed the highest microleakage scores.

For many years, it has been widely recognized that conventional restorative materials and techniques often fail to achieve a perfect marginal seal. Numerous studies have shown that fluid leakage can occur between the restoration and the prepared tooth surface. Marginal voids are a primary cause of failure in resin-based restorations, as the durability of these restorations is significantly reduced when the bond between the resin and the internal cavity walls is unable to prevent microleakage. [13]

Achieving optimal marginal adaptation in adhesive restorations requires careful consideration of several factors, including cavity preparation design, polymerization shrinkage of the composite, and the bonding strength of the dental adhesive. Incremental placement of resin composite has been recommended to minimize the volume of material polymerized at one time and thus reducing C factor. This technique enhances various properties of the restoration, including material density, adaptation to cavity walls, depth of cure, and overall hardness of the composite. [13-15]

In this study we used, Tetric EvoCeram Bulk Fill is composed of an organic matrix made from BisEMA and UDMA (21 vol%) and a filler mix that includes barium aluminum-silicate glass (61 vol%), isofiller ytterbium fluoride, and spherical mixed oxide (17 vol%). Tetric EvoCeram, which includes a patented light initiator, Ivocerin, in addition to camphorquinone which enables fast curing and reducing shrinkage stress during polymerization. [16-17]

The study utilized methylene blue dye penetration, a commonly used and sensitive method for microleakage assessment due to its low molecular weight, affordability, and ease of use. Its molecular size is smaller than that of most bacteria, making it a suitable proxy for assessing the sealing ability of composite resin restorations. [18]

The bulk fill technique, although popular due to its time efficiency and simplified procedure, involves placing a large volume of composite in a single increment. This increases the risk of polymerization shrinkage stress, particularly in high C-factor cavities like Class II restorations, where the ratio of bonded to unbonded surfaces is high [19]. Consequently, the bulk fill group in this study exhibited the highest microleakage scores, consistent with earlier findings by Moorthy et al. and Van Ende et al., who reported compromised marginal adaptation and increased leakage in bulk fill restoration. [20,21]

Through in incremental techniques, light penetration was optimized due to the reduced volume of the polymerized material, hence the light intensity that penetrated into the material was still high and therefore created optimal polymerization. This aligns with Anusavice's observation that increased thickness of composite resin reduces light intensity due to the material's density and its absorption properties. Additionally, applying a second layer of composite resin after the first layer helps to compensate for polymerization shrinkage by filling any gaps formed from the volume reduction of the initial layer.[18]

E. Ozel also emphasized that incremental placement is the preferred technique for restoring posterior teeth with composite resin, as it leads to improved marginal adaptation[22,23]. Additionally, Alster et al. demonstrated that stress relief in thin resin increments is directly related to the amount of resin porosity. The presence of oxygen within air voids often introduced during incremental layering—plays a role in reducing polymerization stress. [22,24]

The oblique layering technique aims to direct polymerization shrinkage toward bonded cavity walls by placing composite diagonally. While this method has theoretical advantages, such as improved stress orientation and reduced gap formation, it is highly technique-sensitive. Improper angulation or curing can lead to incomplete adaptation or voids, which may explain the higher microleakage observed in this group compared to the split and centripetal techniques [25].

The horizontal incremental technique exhibited significantly less microleakage compared to the bulk fill technique. This may be attributed to the smaller volume of composite resin placed in each increment, resulting in reduced stress on the cavity walls. It promotes more uniform and efficient polymerization across the entire depth and reduce C-factor, thereby minimizing polymerization shrinkage. When composite is applied in thin layers, shrinkage occurs within each increment separately, generating less tensile stress. [5]

The centripetal technique demonstrated superior marginal adaptation, likely due to the smaller volume of composite needed to reconstruct the proximal wall. The findings of the present study are in agreement with Szep et al., who reported that even if a gap remained at the cervical wall after forming the proximal wall, the subsequent horizontal increment could effectively flow into and seal the space.Additionally, in the centripetal technique, the initial composite layer does not

come into contact with the pulpoaxial walls. This reduces the tendency of the material to contract toward those walls and away from the cervical floor during polymerization. This characteristic may account for the lower microleakage scores. [7,22]

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. [5]

The split horizontal incremental technique demonstrated lower microleakage compared to both the bulk fill and horizontal incremental techniques. This can be attributed to the diagonal division of the flat composite increment into two triangular segments, which generates additional unbonded surfaces within the material. These surfaces serve as internal reservoirs that allow for material flow or plastic deformation during light polymerization, helping to absorb shrinkage stress and thereby maintain the interfacial bond and marginal integrity of the restoration. [5,26]

Further stress relief occurs by subdividing the large horizontal increment in occlusal and proximal cavities into smaller triangular portions before curing. The reduced increment size and lower configuration factor (C-factor) help to minimize polymerization shrinkage stress by directing it toward the unbonded flow surfaces, rather than the bonded interfaces, which could otherwise contribute to cuspal deflection. [5,26]

Al-Zahawi et al. explained that placing the composite in split increments using two diagonal cuts prevents each portion from simultaneously contacting two opposing cavity walls. This technique reduces the negative impact of polymerization shrinkage stress on the cavity walls and adhesive interface. The unbonded composite surfaces at the diagonal cuts allow for stress dissipation through free flow, thereby minimizing adverse effects associated with shrinkage. [5]

Much of the current literature highlights the importance of eliminating microleakage, a key factor influencing the long-term success of restorations. Based on the limitations of this study, it can be concluded that incremental placement of composite results in reduced microleakage compared to the bulk fill technique. The split incremental technique, in particular, showed better marginal adaptation. However, additional in vivo and in vitro research is necessary to establish the clinical relevance and effectiveness of these techniques.

V. CONCLUSION

- Microleakage could not be eliminated by any of the tested placement techniques despite the significant advances in composite restorations materials and dentin bonding systems.
- Incremental placement technique showed a lower score of microleakage compared to bulk fill technique.
- Among the incremental techniques, split horizontal technique showed least microleakage followed by centripetal placement technique, horizontal technique, oblique placement technique.

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