Original Article

Comparative evaluation of microleakage in Class II restorations using open vs. closed centripetal build-up techniques with different lining materials

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Abstract

Background: Evaluation of microleakage is important for assessing the success of new restorative materials and methods.

Aim and Objectives: Comparative evaluation of microleakage in Class II restorations using open vs. closed centripetal build-up techniques with different lining materials.

Materials and Methods: Standardized mesi-occlusal (MO) and distoocclusal (DO) Class II tooth preparations were preparedon 53 molars and samples were randomly divided into six experimental groups and one control group for restorations. Group 1: Open-Sandwich technique (OST) with flowable composite at the gingival seat. Group 2: OST with resin-modified glass ionomer cement (RMGIC) at the gingival seat. Group 3: Closed-Sandwich technique (CST) with flowable composite at the pulpal floor and axial wall. Group 4: CST with RMGIC at the pulpal floor and axial wall. Group 5: OST with flowable composite at the pulpal floor, axial wall, and gingival seat. Group 6: OST with RMGIC at the pulpal floor, axial wall, and gingival seat. Group 7: Control — no lining material, centripetal technique only. After restorations and thermocycling, apices were sealed and samples were immersed in 0.5% basic fuchsin dye. Sectioning was followed by stereomicroscopic evaluation.

Results: Results were analyzed using Post Hoc Bonferroni test (statistics is not a form of tabulation). Cervical scores of control were more than the exprimental groups ($P < 0.05$). Less microleakage was observed in CST than OST in all experimental groups ($P < 0.05$). However, insignificant differences were observed among occlusal scores of different groups ($P > 0.05$).

Conclusion: Class II composite restorations with centripetal build-up alone or when placed with CST reduces the cervical microleakage when compared to OST.

Keywords: Centripetal build-up technique; closed-sandwich technique; microleakage; open-sandwich technique

INTRODUCTION

Restoring the peripheral seal especially in deep Class II tooth preparations with the gingival margin extending on to the root still remains a critical goal for adhesive dentistry.[1] This peripheral seal is disturbed by the contraction stresses generated in composite resins due to polymerization shrinkage.[2,3] When a tooth preparation extends onto the root surface (non-enamel surfaces), chances of gap formation at the junction of the composite and root surface further increases.[2] This V-shaped gap occurs because the force of polymerization of the composite is greater than the initial bond strength of the composite to the dentin of the root.[2]

Various techniques and materials have been advocated for prevention of marginal gaps in this critical portion such as the use of centripetal build-up technique for incremental additions, compomers, low shrinkage composite[4] or use of stress breaking liners referred to as sandwich technique. The sandwich technique is a layering of materials to create the optimal combination of desirable properties in a restoration. The two variations of this type of restoration exist — open and closed sandwich techniques.[1]

McLean and Wilson[5] first described the open-sandwich technique (OST) in 1977, where glass-ionomer cement (GIC) was left exposed at the cervical margin to allow release of fluoride to protect the surrounding tooth structure. In the

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closed sandwich technique, the GIC is applied to a cavity where complete enamel margins are available for bonding and sealing using the phosphoric acid etch technique. The GIC would be placed to cover the dentin prior to the etching and bonding step.[6] Later on, the use of other materials with this technique like resin modified glass ionomer cement (RMGIC) and flowable composite were also advocated.[7]

To improve the interfacial seal in posterior composite restorations, centripetal build-up technique had been proposed by Hassan K *et al.,* (1987)[8] and later on advocated by Bichacho N (1994).[9] This technique replaces lost tooth structure from the periphery towards the center of the cavity by placement of a thin proximal layer towards the matrix band which is cured first, thereby achieving better marginal adaptation to the cervical margin and decreasing the overall volume/area ratio. This technique can also be combined with sandwich techniques using different materials e.g.; flowable composite, RMGIC, compomer etc.[9]

A combination of these techniques can improve the interfacial seal, especially in preparations with cervical portion extending onto the root portion thus, decrease microleakage at these areas.

Hence, the present *in vitro* study was undertaken to evaluate the microleakage in Class II restorations which were restored with open and closed centripetal build-up technique utilizing different lining materials.

MATERIALS AND METHODS

Selection of teeth

Fifty three non-carious, freshly extracted human mandibular molar teeth of approximately similar dimensions were selected and stored in 1% chloramine-T solution (Hi-media Labs., India) until use. Standardized Class II tooth preparations were prepared on mesial and distal sides of all teeth except one in which no preparation was done on distal side. The dimensions of occlusal box preparation were pulpal depth of 3 mm, bucco-lingual width of 3 mm, and mesio-distal width of 4 mm. In proximal box, bucco-lingual and gingival seat width was 3 mm. Cervical margin of proximal box was placed 1 mm below the cemento-enamel junction (CEJ).

A minimum of 2 mm tooth tissue remained between the two preparations in each tooth. Mounting of teeth were done in metallic jigs and Palodent Sectional Matrix System (Denstply, Switzerland) with wooden wedges were applied before the restorative procedures.

Division of groups

The prepared teeth were randomly divided into seven groups on the basis of restorative technique used.

Group 1: (*n* = 15): Open-sandwich centripetal technique mesio-occlusal (MO with 1 mm flowable composite (Filtek 350 XT flow, 3M/ESPE, USA) at gingival seat of proximal box.

Group 2: (*n* = 15): Open-sandwich centripetal technique disto-occlusal (DO with 1 mm RMGIC (Vitrebond, 3M/ESPE, USA) at gingival seat of proximal box.

Group 3: (*n* = 15): Closed-sandwich centripetal technique MO with 1 mm flowable composite (Filtek 350 XT flow, 3M/ESPE, USA) at pulpal floor and axial wall.

Group 4: (*n* = 15): Closed-sandwich centripetal technique DO with 1 mm RMGIC (Vitrebond, 3M/ESPE, USA) at pulpal floor and axial wall.

Group 5: (*n* = 15): Open-sandwich centripetal technique MO with 1 mm flowable composite (Filtek 350 XT flow, 3M/ESPE, USA) at pulpal floor, axial wall and gingival seat.

Group 6: (*n* = 15): Open-sandwich centripetal technique DO with 1 mm RMGIC (Vitrebond, 3M/ESPE, USA) at pulpal floor, axial wall and gingival seat.

Group 7: (*n* = 15): Centripetal technique MO and DO without any lining material.

After the placement of liners, etching was done by application of 37% phosphoric acid gel (Scotchbond Multipurpose, 3M/ESPE, USA) for 15 seconds. It was rinsed with water for 10 seconds. After removal of excess water with moist cotton pellet, bonding agent (Adper Single Bond 2 Adhesive, 3M/ESPE, USA) was applied as per manufacturer's directions and light cured for 10 seconds with (light-emitting diode, LED) light curing unit (Unicorn Denmart, India). Placement of nano composite (Filtek 350 XT restorative material, 3M/ESPE, USA) was done in circumferential manner along the band, causing resin to climb upwards strictly in contact with the inner surface of matrix band making space for horizontal increments.

Custom-made metallic instrument was used to standardize the technique for centripetal build-up. It was placed in contact with axial wall to standardize the space for centripetal build-up. The increment was then adapted and light cured for 40 seconds. Horizontal increments (1mm thick) were placed to fill the remaining preparation and light cured for 40 seconds. Further, finishing and polishing of occlusal and proximal surfaces were done with sof-lex discs and strips (3M/ESPE, USA) in sequential manner as per manufacturer instructions.

Dye penetration test

The samples were subjected to thermocycling in customized thermocycling device which worked at 500 cycles at 5°C, 37°C, and 55°C, with a dwell time of 30 seconds and transfer time of 15 seconds. The apices were then sealed with modelling wax and two coats of nail polish were applied to coat the foramina and the entire sample surface except for the restoration and 1 mm area beyond the margins. Further, the samples were soaked in freshly prepared 0.5% basic fuchsin solution for 24 hours after which they were thoroughly rinsed under tap water. The samples were then sectioned in mesio-distal direction from center of the restorations with diamond coated disc mounted in straight handpiece (NSK, Eschborn, Germany) under constant water flow. The sectioned teeth were observed under stereomicroscope (Carl Zeiss, Italy) at 12× magnification and evaluated using the ISO microleakage scoring system (ISO/TS 11405:2003).

The scoring criterion for occlusal microleakage scores was as follows:

- 0 = No dye penetration
- 1 = Dye penetration into enamel
- 2 = Dye penetration into the dentin, not including the pulpal wall/gingival floor
- 3 = Dye penetration into the dentin including the pulpal wall

The cervical microleakage scoring criterion was:

- 0 = No dye penetration
- 1 = Dye penetration into ½ of the cervical wall
- 2 = Dye penetration into all the cervical wall
- 3 = Dye penetration into cervical and axial wall

The degree of dye penetration was independently scored by two examiners who were blind to the procedure. In case of disagreement between their evaluations, the worst score was considered. The results were analyzed using Post Hoc Bonferroni test, inferential type of statistics, software Statistical Package for the Social Sciences (SPSS) version 18.0.

RESULTS

On analysis of occlusal scores statistically insignificant differences were observed among the groups [Table 1] ($P > 0.05$). On analyzing cervical scores [Table 2], it was found that the control group (Group 7) without any lining material presented with the least microleakage scores ($P < 0.05$) followed by the Group 4 < Group 3 < Group 1 < Group 5 < Group 6 < Group 2. Among experimental groups, microleakage scores for CST at cervical margin were significantly less than OST ($P < 0.05$).

Table 1: Microleakage at occlusal level

Group	Mean	*n*	Standard deviation
1	0.67	15	0.900
2	0.60	15	0.737
3	0.60	15	0.910
4	0.67	15	0.816
5	0.67	15	0.976
6	0.60	15	0.828
7	0.60	15	0.737
Total	0.63	105	0.823

Table 2: Microleakage at cervical level

Group	Mean	*n*	Standard deviation
1	1.40	15	0.828
2	2.00	15	0.655
3	1.07	15	0.704
4	0.93	15	0.704
5	1.73	15	0.799
6	1.93	15	0.704
7	0.53	15	0.743
Total	1.37	105	0.880

Table 3: Group comparison of groups for microleakage at cervical level using Post Hoc Bonferroni test

Groups compared	*P* value
Group 1 – Group 2*	0.042
Group 1 – Group 3*	0.026
Group 1 – Group 4*	0.053
Group 1 – Group 5	0.350
Group 1 – Group 6	0.081
Group 1 – Group 7**	0.007
Group 2 – Group 3**	0.002
Group 2 – Group 4**	0.001
Group 2 – Group 5	0.281
Group 2 – Group 6	0.781
Group 2 – Group 7**	<0.001
Group 3 – Group 4	0.599
Group 3 – Group 5*	0.036
Group 3 – Group 6*	0.004
Group 3 – Group 7*	0.045
Group 4 – Group 5*	0.012
Group 4 – Group 6**	0.001
Group 4 – Group 7**	0.001
Group 5 – Group 6	0.421
Group 5 – Group 7**	0.001
Group 6 – Group 7**	<0.001

*: Significant, **: Highly significant

DISCUSSION

In the present study on comparison of placement techniques, it was found that microleakage scores were lower at the occlusal margins than cervical margins in all the groups [Table 3]. This could be attributed due to higher inorganic content in enamel which accounts for greater microporosities formation by acid etched, leading to better penetration of adhesive system, and forming a strong micromechanical bond with composite resin.[10,11]

Groups 1, 2, 5, and 6, in which OST was used along with centripetal build-up technique presented with higher microleakage scores. There was no statistically significant difference ($P > 0.05$) between Groups 3 and 4 indicating that both RMGIC and flowable composite were equally effective in preventing microleakage in CST

Regarding the low scores in control group (Group 7) and CST (Groups 3 and 4), the most important reason attributed is reduced volume/area ratio. A thin proximal layer placed towards the matrix band is cured before adjacent composite increments are applied into the cavity, which thereby reduces the volume/

area ratio compared to the situation when the whole margin area is first filled with an increment. Bichacho N and Szep S *et al.,* in their studies concluded that fewer contraction gaps at the margins can be expected using centripetal build-up method.[9,12,13] Also, the first layer of the centripetal build-up technique had no contact to the pulpo-axial walls and thus, had less tendency to contract towards this wall and be shifted away from gingival seat during polymerization.

No significant difference was seen between Groups (1 and 5), (1 and 6), (2 and 5), and (2 and 6) ($P > 0.05$) indicating that extent of lining material has no effect on microleakage scores. The possible reasons for such results could be the weaker bonds between dentin and RMGIC in gingival margin due to the surface not being conditioned prior to RMGIC placement.[14] Secondly, the presence of smear layer must have prevented proper hybridization in this area. McLean JW and Bona AD *et al.,* have stressed on the application of dentin bonding agents before RMGIC placement for better bonding.[5,15,16] Also, it has been seen that etching Glass Ionomer Cement (GIC) before placement of subsequent layer of composite resin leads to deterioration of the GIC matrix.[16,17]

Some researchers state that, RMGIC bonds get distrupted with dentin, mainly in the initial stages of GIC maturation due to contraction forces which occur within polymerizing composite resin. So, the polymerization stress leads to pulling away of RMGIC from dentin and cementum during polymerization of composite resin layer.[10,18-20]

In the OST (Groups 1 and 2), there was statistically significant difference with different groups ($P < 0.05$), with more microleakage in Group 2. Flowable composite performed slightly better as compared to RMGIC. Whereas, in Groups 5 and 6, there was no significant difference ($P > 0.05$) in the use of different lining material to prevent microleakage.

Slightly better results were obtained with nanofilled flowable composites as compared to RMGIC. Flowable composite was placed after conditioning of the gingival seat and it shares the same matrix as the composite (Filtek Z350 XT) which is used as the next increment, thus causing no alteration of matrix. Few authors who support the use of flowable liners in gingival seat of Class II preparation state that these have modulus of elasticity comparable to dentin, making it act like a stress breaker.[13,21]

According to Scholte K and Davidson,[22] the low viscosity resin provides a cross-partial connection with dimethylacrylate present in the restorative material. This connection allows the movement of molecule groups during the initial polymerization which results in a better resin flow and a consequent reduction in the polymerization shrinkage.[13]

Also, the particle size and the viscosity of RMGIC is more as compared to flowable composite and since it is a two component system (powder and liquid) there are more chances for porosities and the microscopic fracture of the material extending from porosity to porosity in the material, leading to increased microleakage.

Within limitations of this study, it can be concluded that none of the placement techniques employed were able to completely eliminate microleakage. Cervical margins showed more microleakage than occlusal. Use of liners in OST and CST on occlusal microleakage scores was found ineffective. Flowable composite used in open sandwich centripetal build-up performed slightly better in terms of reduction in microleakage when compared to RMGIC cement. CST and centripetal build-up alone showed significantly lesser cervical microleakage when compared to open sandwich centripetal build-up technique. Centripetal build-up alone showed significantly less cervical microleakage when compared to all other techniques.

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