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EVALUATION OF MICROLEAKAGE IN POSTERIOR NANOCOMPOSITE RESTORATIONS WITH ADHESIVE LINERS

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ABSTRACT

Microleakage is the clinically detectable passage of bacteria, fluids, molecules or ions between a cavity wall and the restorative materials applied to it. This study was conducted to evaluate and compare the microleakage in Class II nanocomposite restorations, with resin-modified glass ionomer liner (group I), nanofilled flowable composite liner (group II) & without liner (group III). Thirty six non carious upper premolar teeth extracted for orthodontic purposes were selected. Standard class II cavities were prepared. The teeth were then randomly & equally divided into three groups with 12 teeth in each group. The teeth were subjected to thermocycling. After that apex of each tooth was sealed with acrylic resin and the teeth were painted with two coats of nail varnish, except for the area of 2 mm from the periphery of the restorations. The coated teeth were immersed in buffered (pH 7) 0.5% methylene blue dye for 48 hours. Teeth were sectioned & observed under stereomicroscope of 10X magnification. At gingival level, Group I exhibited slightly lesser microleakage than group II but was not statistically significant. Group I showed no significant difference between microleakage at occlusal and gingival level ($Z=1.732$; $P=0.083$). However, in Group II and Group III, there was significantly greater microleakage at the gingival level ($Z= 2.162$ and 3.162; $P= 0.002$ and 0.002, respectively). Both resin-modified glass ionomer and flowable composite can be used as liners under nano composite restorations as reduction in microleakage was comparable.

Key words: Microleakage, Flowable Composite, Glass Ionomer Cements, Methylene Blue

INTRODUCTION

Aesthetic dentistry continues to evolve through innovations in bonding systems, restorative materials, function-based treatment, and minimally-invasive preparation designs. Such advances have increased the myriad of opportunities available to discriminating patients and have provided solutions to many of the restorative and aesthetic challenges faced by clinicians.[1]

Their use in posterior teeth has been recommended for more than 20 years.[2] In recent years, the demand for posterior resin composite restorations has dramatically increased because of their ability to match tooth color, absence of mercury, biocompatibility and bond to tooth structure.[3]

The latest innovations are the development of dental composites based on nanotechnology. The newly available nanomaterials, such as nanofillers and nanohybrids enable the dental composites to be improved.[4] Flowable composites have been recommended as liners beneath composites due to their low viscosity, increased elasticity and wettability. This results in an intimate union with the floors and walls of the cavity preparations. The glass ionomer cement attaches micromechanically to composite and chemically to the dentin. Photocured glass ionomer cement has certain advantages over chemically cured glass ionomer cement like early resistance to moisture contamination, prolonged working time and longer immediate adhesion to dentin.[5,6,7]

Although in vitro and in vivo studies have been carried out with glass ionomers and flowable composites as liners, the efficacy of one over the other is yet to be

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proven. Moreover, recently developed nanocomposite restorative material has not been studied with these liners.

MATERIALS AND METHODS

Specimen Preparation for Microleakage

Sample Size and Teeth Selection

Thirty six non carious upper premolar teeth extracted for orthodontic purposes were selected. The teeth were stored in normal saline soon after extraction and cleaned with slurry of pumice and water prior to preparation.

Cavity Preparation

Standard class II cavities were prepared using a high-speed hand piece (RC-95 BC/RM Highspeed W&H Dentalwerk, Austria) under air-water spray and diamond burs (SS White bur carbide FG 245, SS White FG #34 inverted cone carbide bur). Measurement of the cavity preparations were standardized using metallic scale and calibrated periodontal probe. All teeth were stored in distilled water to prevent desiccation. The teeth were randomly divided into three groups with 12 teeth in each group.

The Experimental Groups

In order to compare the microleakage of the different restorative materials, the experimental groups were divided as follows:

Table 1: Experimental Groups

GROUP 1	Class II nanocomposite restorations (Filtek Z350 Universal Restorative, 3M ESPE) with resin-modified glass ionomer liner (Fuji II LC Improved, GC Dental Corp, Japan)
GROUP 2	Class II nanocomposite restorations (Filtek Z350 Universal Restorative, 3M ESPE) and nanofilled flowable composite liner (Filtex™ Z 350 Flowable Restorative, 3M ESPE, USA).
GROUP 3	Class II nanocomposite restorations (Filtek Z350 Universal Restorative, 3M ESPE) without liner

Restoration Placement Procedure

Group I: Dentin conditioner (GC Dentin Conditioner, GC Dental Corp, Japan) was applied using a cotton pellet as per manufacturer's instructions. Universal Tofflemire matrix band with retainer were adapted to the teeth. Resin-modified glass ionomer liner (GC FUJI LINING LC, GC Dental Corp, Japan) of 1-mm thickness was placed with a cement carrier extending to the full width of pulpal floor, gingival seat, axial wall and light cured for 20 seconds. The remaining walls were etched for 20 seconds with 37% phosphoric acid (Scotch Bond, 3M ESPE, USA) and rinsed with water for 10 seconds and air dried. Two coats of a single component total etch adhesive (Adper™ Single Bond 2, 3M ESPE, USA) was applied with the nylon-bristled brush, as per manufacturer's instructions. Nano composite (Filtek Z350 Universal Restorative, 3M ESPE) was built up in a diagonal increment technique of 2-mm thickness with a plastic filling instrument with each increment cured for 40 seconds (Figure 1).

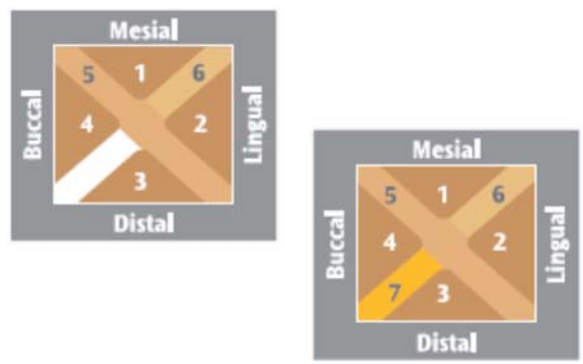

Figure 1: Diagonal increment technique

Group II: Etching enamel and dentin, application of matrix band and single component total etch adhesive application to the etched surface was done as described in group I. One-millimeter thick flowable composite material (Filtex™ Z 350 Flowable Restorative, 3M ESPE, USA) was placed on pulpal, axial walls and the gingival seat as cavity liner the thickness of which was maintained by a groove on the delivery needle. This was light cured for 40 seconds. Then the composite material was placed over the flowable restorative and restored in the same manner as described in Group I.

Group III: The cavities were restored with nanocomposite material without any liner. The same technique was followed as in group I for etching of enamel and dentin, application of matrix band, dental adhesive and placement of composite material.

Light curing was done using Cool Blue™ LED (Milestone Scientific, Livingston, NJ, USA) with a light intensity of 400 mW/cm^2.

Incremental placement techniques are widely recognized as a major factor in the reduction of shrinkage stresses.

Finishing & Polishing

Following completion of restoration, excess composite was removed using a super fine diamond burs and finishing was done with a series of Sof-Lex disks (3M ESPE, USA). The restored teeth of all the three groups were stored in a container of distilled water at room temperature for 1 week.

Thermocycling procedure and dye immersion

The teeth were subjected to thermocycling which consisted of 250 times in water baths maintained at 5ºC, 37°C and 55ºC with a dwell time of 30 seconds. Then the apex of each tooth was sealed with acrylic resin and the teeth were painted with two coats of nail varnish, except for the area of 2 mm from the periphery of the restorations. The coated teeth were immersed in buffered (pH 7) 0.5% methylene blue dye for 48 hours. The teeth were then rinsed with tap water, dried and sectioned mesiodistally through the centre of the restorations using a ultra thin separated carborundum disc with diameter 38mm & thickness 1mm.

Dye penetration evaluation

Each specimen was examined with a stereomicroscope (Advanced Stereo Zoom Microscope, RSMr-10, RADICAL SCIENTIFIC EQUIPMENTS PVT LTD.) and graded according to dye penetration. Dye penetration was measured from both occlusal and gingival margins. Scoring was done by an independent examiner first; observations were confirmed by another trained examiner (Figures 2,3,4).

The scoring criteria were[8]

Occlusal margin

0 = No evidence of dye penetration

1 = Superficial penetration of dye at the margin but less than one-third of the width of mesial/distal wall

2 = Penetration along the margin beyond one-third of the width of mesial /distal wall, up to the pulpal floor

3 = Penetration along the pulpal floor

Gingival margin

0 = No evidence of dye penetration

1 = Superficial penetration of dye at the margin but less than one-third of the gingival width

2 = Penetration along the margin beyond one-third of the gingival width up to the axial wall

3 = Penetration along the axial wall

STATISTICAL ANALYSIS

Data was analyzed using SPSS for Windows release 11.5 (SPSS, Chicago, IL, USA). Kruskal Wallis test was used to assess differences between the groups and Mann-Whitney U test was used to investigate the pair wise differences between different groups. Wilcoxon Signed Rank test was used for statistical analysis of values at occlusal and gingival levels.

MICROLEAKAGE SCORING

The total number of each score in each group was

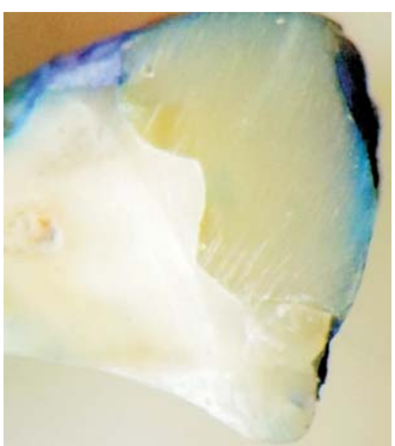

Figure 2: Group I (RMGI LC)

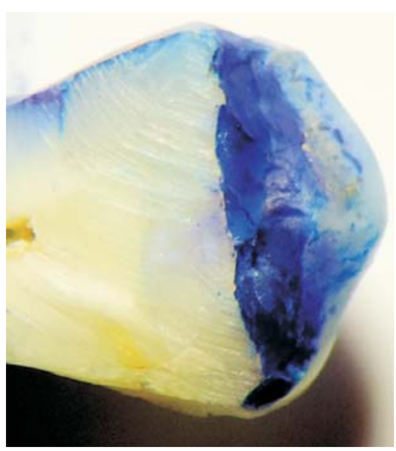

Figure 3: Group II (FILTEK Z350)

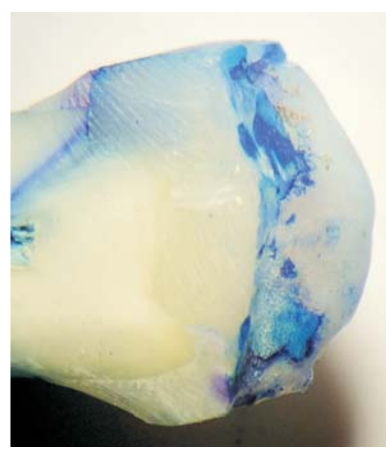

Figure 4: Group III (CONTROL)

Table 2: Distribution of dye penetration scores at the occlusal and gingival level

SCORES FOR DYE PENETERATION	GROUP I RESIN MODIFIED GLASS IONOMER CEMENT(GC FUJI LINING LC)		GROUP II FLOWABLE COMPOSITE(FILTEK Z350 FLOWABLE RESTORATIVE)		GROUP III CONTROL (WITHOUT LINER)		TOTAL	
	Occluasal	Gingival	Occluasal	Gingival	Occluasal	Gingival	Occluasal	Gingival
0	5	4	6	1	1	0	12	5
1	5	5	5	5	4	1	14	11
2	2	2	0	5	5	4	7	11
3	0	1	1	1	2	7	3	9
Total	12	12	12	12	12	12	36	36

calculated and is represented in Table 2 for dye penetration.

From the summarized results, it is clear that RMGI LINING LC Group had the highest count of zero scores (9) amongst the materials tested, implying that these specimens showed no microleakage at all. Flowable composite (filtek Z350) had the highest number of specimens (6) with a score of 0 at occlusal level & Group III (CONTROL WITHOUT LINER) showed maximum no. of scores of 3 (maximum microleakage) at gingival level (7). This indicates the better sealing ability of RMGI & Flowable composite over the control group.

RESULTS

KRUSKAL-WALLIS test revealed that there was statistically significant difference in microleakage between the groups at both occlusal ($\chi 2$ = 8.689; P=0.013) and gingival levels ($\chi 2$= 13.372; P=0.001).

According to WILCOXON SIGNED RANK TEST, At gingival level, Group I exhibited slightly lesser microleakage than group II but was not statistically significant. Group I showed no significant difference between microleakage at occlusal and gingival level (Z=1.732; P=0.083). However, in Group II and Group III, there was significantly greater microleakage at the gingival level (Z=2.162 and 3.162; P=0.002 and 0.002, respectively).

DISCUSSION

Recent advances in resin adhesives and restorative materials, as well as an increased demand for esthetics, have stimulated a great increase in the use of resin-based composites in posterior teeth.[9]

Poor marginal adaptation along the cervical margins, secondary caries, material fractures and inadequate wear resistance under masticatory loads have been established as the common clinical problems of posterior resin composite restorations.[10,11]

These problems reflect drawbacks in the resin composite restorative materials and their adhesive systems. The nanocomposites based on nanotechnology are the latest innovations to address the shortcomings that have been identified.

In this study every effort to simulate the clinical situation as closely as possible was undertaken.

In this study, the resin modified glass ionomer liners in Group I were not acid etched as it causes weakening of the cement matrix.[12] Also, resin-modified glass ionomers chemically bond with resin composites which is enhanced by placement of adhesives.[13] The diagonal increment technique used in this study minimizes the stress at resin-tooth interface. By placing successive layers of apicoocclusal wedges of composite, the C-factor for each layer is decreased, thus decreasing the overall polymerization shrinkage.[14]

In the present study all the tooth preparation was done to be present on enamel. Enamel has been regarded as a reliable substrate for bonding. Bonding to dentine is far more difficult and less predictable than bonding to enamel because dentine is about 75% inorganic in nature as opposed to enamel that is 95% inorganic.[15]

According to the manufacturers Filtek Z350 universal restorative displayed very low shrinkage, averaging 2.09%.Van Meerbeek et al, reported that the flexibility and elasticity of the bonding layer provides a gradient of elasticity between the resin bonding areas that may absorb the stresses induced during polymerization.[16]

Effective bonding requires removal of the smear layer with acids followed by rinsing and drying of the preparation for a clean, adequately moist surface before application of the bonding agent.[17]

The results of this study potentiate the importance of using liners under nanocomposite restorations, as the group without liner showed significantly higher microleakage. Polymerization shrinkage of nanocomposites can produce cracks at the resin-tooth interface, which contribute to microleakage. Both resin-modified glass ionomer liners and flowable composite liners have lower modulus of elasticity and hence deform and/or flex to a degree when subjected to an external force.[18] This characteristic is thought to attenuate shrinkage stress from the subsequently placed higher modulus composite restoratives. Also, application of liners reduces the volume of composite and configuration factor (C-factor) of the cavity.[13] Although resin-modified glass ionomer has low tensile strength compared to composite leading to cohesive failure, the effect of low tensile strength was reduced by using resin-modified glass ionomer as a thin liner.[19] Some of the previously published studies[20,21] have reported that flowable composites as liners under posterior composites do not significantly reduce microleakage. Despite their low elastic modulus, the contraction stress generated during curing process pulls the flowable composite away from the tooth wall leading to gap formation and microleakage.[21] But findings from this study revealed that flowable composite lining improved marginal adaptation of composite compared to group without liner. Perhaps the relatively thin layer of liner used in this study would have minimized the effect of polymerization shrinkage. Chuang et al concluded in their study that use of 0.5-1.0 mm thick layer of flowable composites liner under packable composite restorations results in significant reduction in microleakage.[22] However, use of liners did not totally prevent microleakage.

Among the group with liners, 33.33% specimens showed dye penetration at the occlusal level, and 52.8% at gingival level. Findings from this study support the findings of earlier studies,[23,24,25] which demonstrate that gingival margins are potentially a greater source of microleakage in class II composite restorations compared to occlusal margin. Another reason for increased gingival microleakage relates to the distance of light source from the material at the proximal box base as compared to occlusal surfaces.[24] Resin modified glass ionomer group was better than others in this respect as there was no statistically significant difference in microleakage between occlusal and gingival margins.

Microleakage at gingival level was more in flowable liner group when compared to resin-modified glass ionomer group, but not statistically significant in this study.

The intrinsic porosity and water sorption of the resin modified glass ionomer can compensate for polymerization shrinkage.[26] Use of syringe delivery system for flowable composites as compared to hand instrument for resin modified glass ionomer may have contributed to better adaptation of flowable composite to cavity walls resulting in comparable levels of microleakage in this study.

CONCLUSIONS

Under the conditions of this in vitro study. Gingival margins are more susceptible to microleakage than occlusal margins in class II cavities.

Placement of 1-mm thickness liner beneath nanocomposite restorations results in significant reduction in microleakage but does not totally prevent it.

Both resin-modified glass ionomer and flowable composite can be used as liners under nano composite restorations as reduction in microleakage was comparable.

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