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An In-Vitro Stereomicroscopic Evaluation of Microleakage in Class II Open-Sandwich Restorations Using Resin Modified Glass Ionomer Cement & Zirconomer

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ABSTRACT

***Context:** Evaluation of microleakage is important for assessing the success of newer restorative materials. Aim: To evaluate & compare microleakage in deep class II restorations using open-sandwich technique with two different liners at tooth-liner interface & liner-restoration interface. Materials & Method: Forty non-carious premolars were selected and randomly divided into two groups (n=20). A mesio-occlusal class II cavity preparation was made with the cervical margin 0.5-1mm below the cemento-enamel junction in all the samples. Zirconomer was used as base in Group I and Resin modified glass ionomer cement (RMGIC) in Group II followed by composite resin restoration in both the groups. Teeth were then subjected to thermocycling in 5°C and 55°C water baths. Root apices were sealed and samples were immersed in 0.5% methylene blue dye. Teeth were sectioned in mesio-distal direction and observed under stereomicroscope. The data was collected and results were analyzed using Mann Whitney U test. Results: Zirconomer showed significantly higher microleakage ($p < 0.05$) as compared to RMGIC at tooth and liner interface. Statistically non-significant difference ($p > 0.05$) was observed between the groups at the liner-restoration interface.*

Conclusion: Resin modified glass ionomer cement proved to be better than Zirconomer as liner in deep class II preparations.
Keywords: Bulk-fill composite; Microleakage; Open-sandwich technique; Thermocycling

INTRODUCTION

Restoring the proximal contacts in Class II preparations with gingival margin extending onto the root still remains a challenging task in restorative dentistry. The proximal contact is disturbed by the contraction stresses generated in composite resins due to volumetric shrinkage[1,2]. When a tooth preparation extends onto the root surface, chances of gap formation at the junction of the restoration and tooth surface further increases. This in turn can lead to postoperative sensitivity, marginal fracture, secondary caries and eventual bond failure[3]. The above discussed problems will eventually lead to microleakage between cavity wall and restoration. Different techniques and materials have been advocated for prevention of marginal gaps in this critical portion. One such technique is sandwich technique (open & closed).

The sandwich technique is the layering of materials to create the optimal combination of desirable properties in a restoration[2]. In 1977, *McLean and Wilson* described the open-sandwich technique where glass-ionomer cement was left exposed at the cervical margin to allow release of fluoride to protect the surrounding tooth structure[4]. It reduces the amount of composite that is needed there by reducing the shrinkage. It provides chemical adhesion to the tooth, it has a lower modulus of elasticity, hence, can act as an elastic buffer or a stress-breaking barrier & it also reduces postoperative sensitivity[5].

However, this restoration is associated with certain drawbacks like the limited bond strength between composites and conventional GIC. Sandwich restoration with conventional GIC as a liner showed failure rates of 35% after two years and 75% after six years[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]. Resin-modified GIC (RMGIC) had proven to exhibit a true adhesive bond in previous literature reports[8].

Zirconomer is the newly introduced restorative material incorporated with yttrium stabilized zirconia particles, claimed to have strength and durability of amalgam, along with bondable and fluoride releasing property of glass ionomer cement. It chemically bonds to enamel/dentin and has tooth-like co-effcient of thermal expansion resulting in low interfacial stresses and long-lasting restorations in stress bearing areas[9]. As there is negligible documentation of zirconomer used as a dentin replacement material in deep class II restorations, this study was undertaken.

The study was done to evaluate and compare microleakage in Class II open sandwich restorations with two different lining materials Zirconomer & RMGIC -

1. At tooth-liner interface (Tooth & Zirconomer/ RMGIC)
2. At liner and restoration interface (Zirconomer/RMGIC & Composite Resin)

The null hypothesis tested was that there would be no difference in microleakage scores between the two groups at tooth-liner interface and at liner and restoration interface.

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MATERIALS AND METHODS

Selection of teeth

Institutional ethical clearance was taken before conducting the study. This in-vitro study design consisted of a collection of 40 human maxillary premolars free of caries, restoration and visible cracks extracted for orthodontic or periodontal reasons. Teeth were stored in chloramines-T solution (Himedia Labs, India) until use, for not more than one month.

A standardized mesio-occlusal Class II conventional tooth preparations were made using pear shaped No. 245 tungsten carbide bur (SS White, Germany) which has a diameter of 0.8mm using high speed air-rotor handpiece (NSK, Germany). The pulpal depth, bucco-lingual width and gingival seat width of 2 mm and axial wall height of 3mm extending 0.5-1mm apical to CEJ (Figure 1) was maintained in all the samples and dimensions were verified with William's graduated periodontal probe.

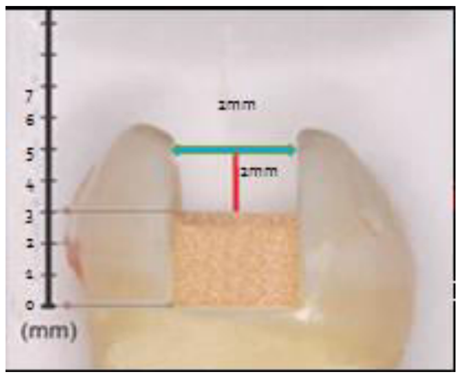

Figure 1. Standardized dimensions of the class II cavity preparation

Division of Group

The prepared teeth were randomly divided into two groups of 20 each on the basis of liner material used-

Group 1: Automatrix was applied that allowed building up of the proximal wall. Zirconomer (SHOFU INC, Kyoto, Japan) was applied as liner (1 mm thickness) covering pulpal floor, axial wall and gingival seat. After application of liner, acid etching was carried out using 37% phosphoric acid for 15 seconds and was thoroughly rinsed (10 seconds) and dried. Bonding agent (Tetric N-Bond, Ivoclar Vivadent AG, Schaan/Liechtenstein) was applied on all surfaces (dentin, enamel, and base) and light cured for 20 seconds.

Teeth were restored with bulk fill composite resin restoration (Tetric N-Ceram, Ivoclar Vivadent AG, Schaan/Liechtenstein).

Group 2: The cavities were conditioned with 10% polyacrylic acid (liquid supplied with Fuji II LC) for 20 seconds, followed by rinsing the cavities thoroughly with water for 20 seconds and air dried. Automatrix retainer and band was adapted to the tooth and 1mm thick layer of Fuji II LC (GC; Tokyo, Japan) was applied as liner similar to Group I and light cured for 20 seconds. The restorative procedure was carried out as described for group I.

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The samples were stored in normal saline for 24 hours followed by polishing of the restorations using Composite polishing kit (Shofu Co. Japan).

Thermocycling and microleakage testing

The samples were thermocycled for 500 cycles between 5°C ± 2°C and 55°C ± 2°C with dwell time of 20 seconds[10]. The root canal apices were sealed using sticky wax followed by painting of entire tooth surface with two coats of nail varnish to within 1mm of the restoration margins. The teeth were immersed in 0.5% methylene blue dye for 24 hours and rinsed with water. Samples were sectioned in mesio-distal direction through the center of the bulk of restoration with No. 1 grit diamond disk using a straight hand piece (NSK, Eschborn, Germany) and observed under stereomicroscope (Carl Zeiss, Italy) at 12X magnification.

The dye penetration was evaluated at the tooth–liner interface and at liner-restoration interface. The microleakage scoring criterion used was[1]:

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

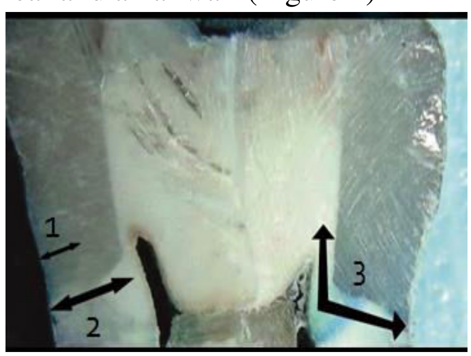

Figure 2. Different microleakage scores

Microleakage scores were independently assessed by two different examiners blinded to the two groups. Mean average score values assigned by both the examiners were considered for statistical analysis.

STASTICAL ANALYSIS

Statistical analysis was carried out using Mann Whitney U test. SPSS21.0 software was used and $p<0.05$ was considered as level of significance.

RESULTS

	Groups	N	Mean	Std. Deviation	Std. Error Mean	z-value	p-value
Tooth & liner interface	Group I	20	2.94	0.22	0.05	8.44	0.0001,S
	Group II	20	0.89	1.10	0.25		

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Liner & restoration interface	Group I	20	0.25	0.24	0.09	2.01	0.058, NS
	Group II	20	0.05	0.22	0.05		

S= significant, NS = non significant

Table 1. Mann Whitney U Test determined microleakage values.

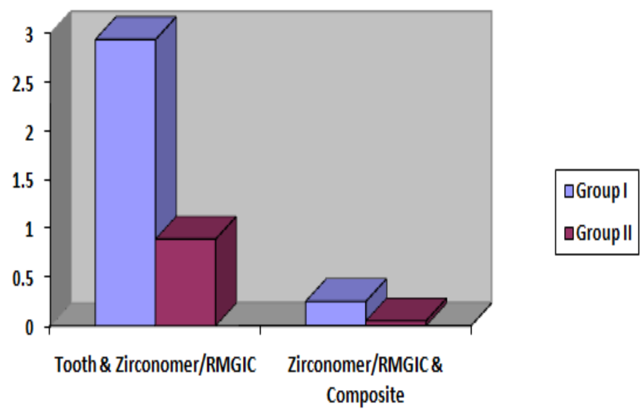

Figure 3. Mean microleakage scores of both the groups

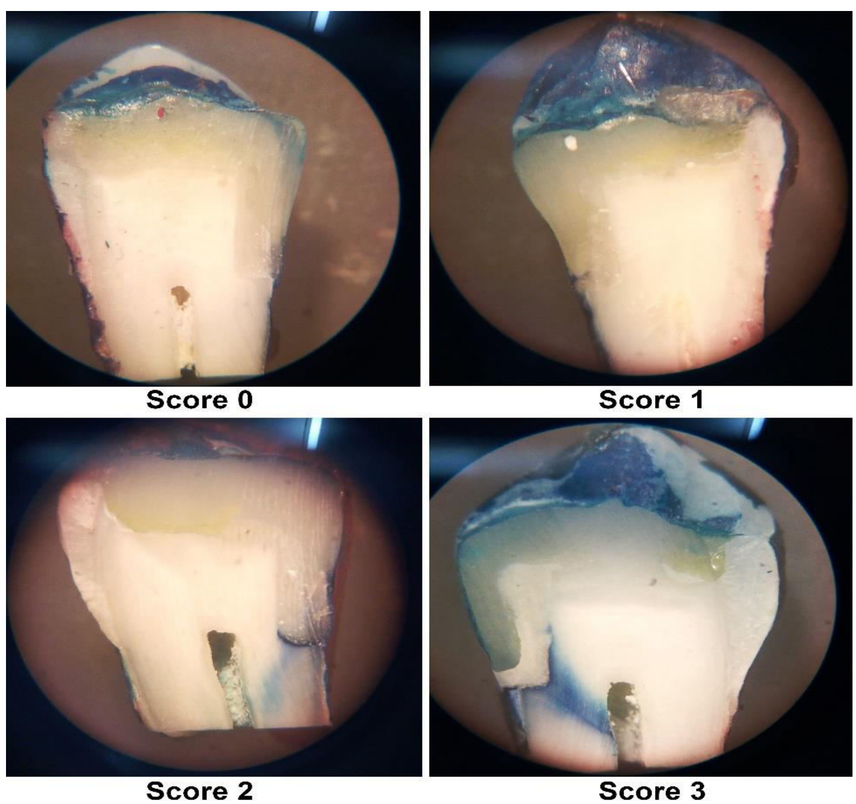

Figure 4. Stereomicroscopic images of different microleakage scores

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Table 1 and Figure 3 depicts the scores of microleakage of both the group at tooth-liner interface and between liner-restoration interface. Figure 4 displays the stereomicroscopic images ofdifferent obtained scores.

According to the result, Zirconomer showed higher microleakage (2.94) as compared to RMGIC (0.89) which was statistically significant ($p< 0.05$) at tooth and liner interface. However, a non-significant difference ($p>0.05$) was observed in both the groups at the liner-restoration interface. RMGIC showed less microleakage (0.05) as compared to Zirconomer (0.25).

DISCUSSION

Assessment of microleakage is a critical step which is directly related to the success or failure of the restorative materials. Microleakage may provoke sensitivity due to interfacial hydrodynamic phenomenon leading to microorganisms colonization and increased incidence of secondary caries resulting in restoration failure[11,12]. Microleakage is the most significant disadvantage associated with the use of composite resin restorative materials[13].

Numerous methods are available to check microleakage such as use of air pressure, dyes, radioisotopes, fluid transport device, electrochemical method, resin infiltration method, electron microprobe etc.[14]. In the present study, dye penetration method was used to evaluate the microleakage between tooth and Zirconomer/RMGIC liner and between Zirconomer/RMGIC liner and composite resin. Dye penetration method was selected because it is reliable, easy and commonly used method to detect the microleakage. Low cost, ease of application and low molecular weight of dye made us to select methylene blue for our study. Due to its low molecular weight, it can easily penetrate in microspaces between the various interfaces[15].

Thermocycling was done to mimic the intraoral temperature variations. It is a standard protocol in restorative dentistry when bonded materials are evaluated, simulating in vivo aging by subjecting them to cyclic exposures of hot and cold temperatures[16, 17].

Resin-modified glass ionomer was used because inclusion of resin in the Glass Ionomer formulation allowed this material to polymerise upon light activation. The resin also supplemented the chemical bond that Glass ionomer achieves with tooth structure by bonding micromechanically. This double adhesion mechanism is the main determinant of the retention and marginal sealing capacity of the material. A further advantage of using Resin-modified glass ionomer cement is its fluoride releasing property, which is considered to have some inhibitory effect on caries formation and progression around the restoration[18,19,20].

Zirconomer is a new class of glass ionomer restorative material. Chemical bonding, excellent strength, long sustainability and fluoride release makes it an ideal restorative material in patients with high caries index. Addition of zirconia as filler particle in the glass component of Zirconomer improves mechanical properties of the restoration by reinforcing structural integrity of the restoration in load bearing areas[21]. The mechanical properties of this Yttrium stabilized restorative material may be high because of continuous formation of Aluminium salt bridges, which improved the strength of the cement[9].

Many studies were done on microleakage of GIC, RMGIC and composite, but since there are limited studies on use of zirconomer as a liner in deep Class II restorations, this study was undertaken. In the present study, significant difference was seen between the groups at the tooth and RMGIC/ Zirconomer liner interface indicating that lining material has potential effect on microleakage scores. RMGIC showed less microleakage as compared to Zirconomer. Our result is in agreement with the studies conducted by Karaman E et al.[22] and Makkar S et al.[23] which showed placement of RMGI liner reduces microleakage and can be used as an intermediate material below composite restorations.

Result of the present study rejects null hypothesis that there is no difference in microleakage scores at tooth-liner interface. The possible reasons for such results could be due to the presence of smear layer between tooth and zirconomer which has resulted in weak interface between them as there is no surface modification done with the zirconomer group to remove or alter the smear layer unlike RMGIC group.

RMGIC proved to be better because of formation of resin tags by RMGIC into dentinal tubules allied to the ion exchange process present in the interface between dentin and RMGIC[24]. In addition, the presence of HEMA in the RMGIC is responsible for the increased bond strengths to resin composite[25]. Restorations made with RMGI cements used in the open sandwich technique are more tolerant towards "temperature/relative humidity" parameters, which might have simulated intra-oral conditions[26].

In our study, RMGIC showed less microleakage as compared to Zirconomer at the liner-restoration interface. However, no significant difference was seen between the groups which could be attributed to the less gap formation i.e. good bonding strength of composite resin to the glass ionomer component of both the restorative material. This result supports our null hypothesis at liner-restoration interface.

In the present study, Zirconomer exhibited higher microleakage as compared to RMGIC at both the tooth-liner interface and between liner- restoration interface. Thus, placement of RMGIC as a liner could be considered as a viable modality in class II composite restorations when margins are placed apical to CEJ to reduce microleakage.

The reliability of in-vitro research depends upon the extent of simulation of the oral cavity conditions. So, this study emphasized to simulate in vivo conditions by thermocycling to accelerate adhesive or cohesive failure. Thermocycling can increase dye penetration and gap formation, which means we would have greater certainity in applying the present study result to clinical conditions.

CONCLUSION

Within limitations of the study, Resin Modified Glass Ionomer Cement proved to be better than Zirconomer as liner in deep class II restorations. However further research is needed to support these findings.

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