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Original Research Article

Evaluating Microleakage of class II Composite Resin Restorations through various restorative approaches -An Invitro study

Somayeh Hosseini Tabatabaei[1], Mohsen Tamandi[2], Mohammad Naebi[3]

[1]Assistant professor of operative dentistry, oral and dental disease research center, Zahedan University of medical sciences, Zahedan, Iran

[2]School of Dentistry, Zahedan University of Medical Sciences, Zahedan, Iran

[3]School of Dentistry, Tabriz University of Medical Sciences, Tabriz, Iran

***Corresponding author**
Somayeh Hosseini Tabatabaei
Email: so_tabatabaei@yahoo.com

Abstract: Using posterior composite restorations will cause some problems, since in these trends high viscosity and polymerization shrinkage exist. To reduce these problems, several methods have been suggested. Hence, this study aimed to compare the gingival microleakage of Class II composite restorations that cover apical to the cemento-enamel junction (CEJ), through three restorative methods, Conventional, Open sandwich and Snow plow. This in vitro study included 40 class II cavities in 20 extracted intact human premolars. Gingival margins were located within 1 mm apical to CEJ. The samples were divided into four groups randomly and were filled through different methods. Group 1: P60 Packable composite. Group 2: RMGI (Resin modified glass ionomer, Fuji II LC) with thickness of 1mm. Group 3: in this group flowable composite (Filtek Flow) with thickness of 1mm was cured. Group 4: flowable composite with 0.5 mm thickness without curing, along with 0.5 mm packable composite, which then they cured together. In all groups, remained space of cavities was packed by packable composite. All samples were thermo- cycled and then were immersed in 0.5% basic fuchsin and evaluated dye penetration. Data were analyzed through Kruskal-Wallis and Mann-Whitney test at $p < 0.05$. In group 1 microleakage was significantly higher than other groups, and no significant differences were found between groups 2, 3 and 4. The results revealed that, the application of intermediate layers between resin composite and dental substrates results to decrease gingival microleakage.

Keywords: Microleakage, Composite resin, Glass Ionomer.

INTRODUCTION:

The marginal seal is one of the most important factors, which affects the success of a restoration. One of the main factors that distress the success of restoration through applying resin composites, is the characteristic polymerization of resin composites [1]. Resin composites contain advantages such as: esthetic, bonding, thermal insulation, conservative cavity preparations and strengthening the remained tooth structure and lack of mercury, hence, these materials have found many applications [2, 3.

Considering the homogeneity of enamel, the strength of enamel- composite bond would be reliable. However, the main problem is dentin- composite bond, particularly when the margins extend beyond the Cemento Enamel Junction (CEJ) [2-5]. In these areas, polymerization shrinkage of resin composites might causes the formation of gaps between the restoration and tooth structure (microleakage) and it results to tooth hypersensitivity and pulpal damages [6]. Finding a method or material which minimizes the potential microleakage with proper bond to tooth structure, has always made researchers be interested in this filed [7]. Some methods including Sandwich and snow plow are suggested to reduce the polymerization shrinkage [6, 8].

In some studies it was revealed that the intermediate layer of bonding agent or a flexible intermediate layer even with the thickness of 150 microns between the composite and tooth structure can reduce the final tension to 18% - 50% and this amount is important to decrease the microleakage. This is the basis of applying Flowable composites as an intermediate layer [8]. Furthermore, the amounts of filler have been increased in packable composites and these materials are proposed in areas with high occlusal stress [9]. However, the high viscosity of these composites is the main problem that makes poor adaptation, particularly in deep zones. The use of flowable composites as an intermediate layer is proposed to overcome this problem. While, the consequence of this technique has not completely been proven yet [9, 10].

Considering the advantages and disadvantages of each method and material, the choice of a method with the greatest advantages and lowest microleakage plays a great role. Hence, this study aimed to compare the gingival microleakage of Class II composite resin restorations that extend beyond the CEJ through three different methods. These methods include: conventional, open sandwich (sandwich with RMGI, sandwich with flowable composite) and Snow Plow. The microleakage in the sandwich method using two intermediate composite materials flowable and RMGI were investigated in a study in 2011. In this work, no significant difference was found in microleakage within different groups. Increasing the thickness of the intermediate layer, no difference was found in the rate of leakage [11].

In a study in 2009, the use of flowable composites, as an intermediate layer was studied and it was found that this method was significantly effective in reducing the microleakage compared with non-use of such materials [12].

The methods of the leakage in 4 Etch and Rinse dentin bonding and 3 Self etch dentin bonding methods with presence and absence of flowable composites, were investigated by Gueders *et al.;* in 2006. The results revealed that no significant differences exist between the micro leakages of two groups [13]. In a study in 2013, it was shown that, using the flowable composite as a liner may not advance marginal adaptation and it depends on product. Lining the cavity with a 1-mm-thick layer of a bonding agent advances the marginal adaptation, however, it may be problematic clinically [14].
In a study in 2013, it was found that, using either conventional or new-generation flowable composite resin as an intermediate material does not influence the Microleakage [15].

MATERIALS AND METHODS:

Choosing and preparing the teeth:

Twenty extracted human premolars, with no caries, restorations, cracks or other defects were selected. Any calculus or soft tissue debries were removed from the teeth, using an ultrasonic scaler and stored in physiologic saline with 0.05% sodium azide at 5°C for more than four months before applying.

Preparing the Class II cavities on the mesial and distal surfaces:

Preparing the Class II cavities was conducted on both mesial and distal surfaces of each tooth using a fissure diamond bur in a high speed hand-piece with air and water spraying in the following dimensions:

Mesiodistal width: 2 mm, buccolingual width: 3 mm, gingival margin placed 1 mm apical to the CEJ. Using periodontal probe, the cavity dimensions were controlled (Hu-Friedy Co, Chicago, USA). After preparing the four cavities, the bur was replaced. The prepared teeth were rinsed in tap water and stored in distilled water until restoring. The teeth were randomly divided into four groups.

Then, the teeth were restored in different groups:

1. Conventional group: First, the tooth was rinsed and dried. The metal matrix band (Tofflemire, Kerr Hawe SA, Bioggio Switzerland) was placed around the tooth, so that the Gingival margin of matrix band was placed 1 mm below the gingival margin. Then, phosphoric acid, (Ultra-Etch 35%, Ultradent products Inc, USA) was applied on the enamel and then on dentin surfaces, so that these surfaces were etched for 30 and 15 seconds, respectively. All the surfaces were rinsed for 20 seconds with air-water spray. Using gentle air pressure the excess water was removed. A semi-moist cotton ball was used on dentin surfaces after drying to avoid excessive drying of dentin surfaces. The bonding agent (Adper Single bond, 3M ESPE, USA) was rubbed for 10 seconds and it was air-dried, then the second bonding layer was applied and light-curing was performed with an intensity of 450 MW /cm2 for 20 seconds using light-curing device (Coltolux 75, Coltene Whale dent Inc, USA). The intensity was adjusted using a radiometric device (Coltene Whale dent Inc, USA). Then, the cavity was resorted horizontally in three increments using P60 composite resin (3M, ESPE, USA).

The first layer of composite filled the CEJ (1mm thickness), the second layer filled the half occlousogingival height of the cavity and the third layer filled the remaining space of cavity. Each layer was cured within 40 seconds curing time with the intensity of 450 MW/cm2. Then the matrix was removed, and each Buccal and lingual surface of the proximal cavity was cured for 40 seconds. Using flame shaped carbide bur the excess composite was removed and it was polished with mullet. All teeth samples were stored in distilled water at 37 ° C.

2. Open sandwich with RMGI: A matrix band, similar to that in group 1, was applied. In this group, the intermediate layer was RMGIC (Fuji II LC, Tokyo, Japan). The RMGIC was mixed according to the manufacturer's instructions and it was located on the gingival floor with a thickness of approximately 1 mm (up to CEJ), then it was cured for 40 seconds from occlusal surface. Then the etching, bonding, and restoring procedures were performed in the cavity with P60 composite, similar to group 1.

3. Open sandwich with flowable composite: A matrix band, similar to that in previous groups was applied. After etching and bonding, FRC (Filtek flow, 3M ESPE, USA) was injected onto the gingival floor with a thickness of approximately 1 mm (up to CEJ) and it was light cured for 40 seconds from occlusal surface, similar to group 1. The remained space of cavity was filled similar to group 2 with P60 composite.

4. Snowplow method: A matrix band was used similar to that in previous groups. The etching and bonding procedures were similar to group 1. The flowable composite (Filtek flow, 3M ESPE,USA) was injected onto the gingival floor of with the thickness of approximately 0.5 mm, however, this layer was not cured, then the P60 composite placed on flowable composite with the thickness of approximately 0.5 mm (up to CEJ). Then two layers cured for 40 seconds together. The remaining space of cavity was filled similar to group 3 with P60 composite.

The samples were thermocycled between 55±2 ° C and 5±2 ° C (dwell time of 30 seconds) for 500 cycles following 24 hours placement in distilled water. Staining, Using sticky wax, the root apices of the teeth were sealed. The surfaces of all teeth were coated using two layers of nail varnish within approximately 1 mm of the margin of the restoration. Then the teeth were submerged in 0.5% basic Fuschin solution for 48 hours at 37 ° C.

Sectioning and measuring of the microleakage:

The dye was removed from the teeth, then the teeth rinsed in tap water, dried for two minutes and mounted in epoxy resin (Epofix, EMS, and Fort Washington, PA, USA). Using a diamond disk (Diamat, Germany) with a thickness of 0.5 mm, the mounted samples were sectioned buccolingually through the center of the tooth. The sectioned specimens were tested using a microscope with the magnification of 25x.

Based on the following scales, the degree of microleakage at gingival margins was graded: Score 0 = No dye penetration
Score 1 = Dye penetration within ½ gingival floor,
Score 2 = Dye penetration beyond the ½ gingival floor rather than the axial wall
Score 3 = Dye penetration within ½ axial wall
Score 4 = Dye penetration in the whole axial wall

Data Analysis:

Mean ranking and the scores of microleakage distribution frequency were calculated for each group. The data were analyzed using SPSS 19 software. Data was statistically analyzed using non-parametric Kruskal-Wallis test and Mann-Whitney U test under a significance level of 0.05.

RESULTS:

Table 1 represents the mean and standard deviations of microleakage scores for all groups, and they were shown in Figure 1. The results revealed that, the highest (Mean Rank =27.80) and lowest (Mean Rank =17.30) dye penetration was related to teeth restored using conventional and snowplow methods, respectively. The Kruskal-Wallis test showed that there is a statistical significant difference between four groups (P=0.091) (Table 1).

Further analysis using the Mann-Whitney U test showed that there are significant differences in mean microleakage scores between the control groups and the other groups ($p<0.05$) (Table 2). Using the Mann-Whitney U test, significant differences were shown in mean microleakage scores between the conventional group and Open sandwich (RMGI) (P=0.016). Using the Mann-Whitney U test, it was shown that there are significant differences in mean microleakage scores between the conventional group and Open sandwich (Flowable)(P=0.022). Significant differences were shown using the Mann-Whitney U test in mean microleakage scores between the conventional group and snowplow (P=0.042).

Using Mann-Whitney U test no significant differences were shown in mean microleakage scores between the Open sandwich (RMGI) and Open sandwich (Flowable) (P=0.397). Using the Mann-Whitney U test no significant differences were shown in mean microleakage scores between the Open sandwich(RMGI)and snowplow(P=0.521). No significant differences were found in mean microleakage scores between the Open sandwich (Flowable) and snowplow (P=0.868), using the Mann-Whitney U test.

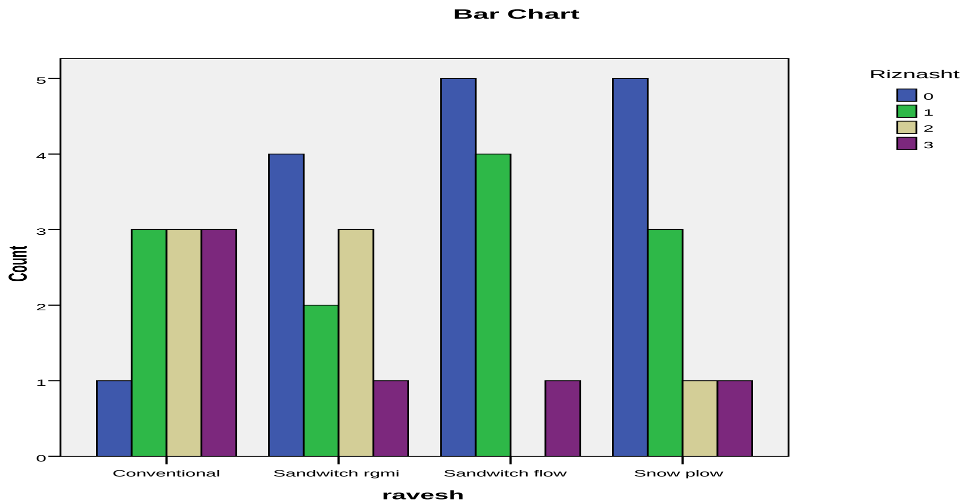

Table 1: Comparison of the frequency and average colors penetration rate in different restoration groups

Dye Penetration and Restoration Method	Score 0		Score I		Score II		Score III		Score IV		Total		Mean Ranks	P-Value
	Frequency	percentage	Frequency	percentage	Frequency	percentage	Frequency	percentage	Frequency	percentage	Frequency	percentage		
Conventional	1	10	3	30	3	30	3	30	0	0	10	100	27.80	
Open sandwich (RMGI)	4	40	2	20	3	30	1	10	0	0	10	100	20.55	P = 0.091
Open sandwich (Flow-able)	5	50	4	40	0	0	1	10	0	0	10	100	16.35	
Snow plow	5	50	3	30	1	10	1	10	0	0	10	100	17.30	
Total	15		12		7		6		0		40			

Table 2: Pairwise comparison of dye penetrations between the different groups in the gingival surface

	Conventional	Open sandwich (RMGI)	Open sandwich (flow- able)
Conventional	-	-	-
Open sandwich (RMGI)	P= 0.16	-	-
Open sandwich (flow- able)	P= 0.022	P= 0.397	-
Snow plow	P= 0.042	P= 0.521	P= 0.868

DISCUSSION:

Resin composites have been improved in all fields, including aesthetics, wear, and handling. However, the high-polymerization shrinkage of these materials leads to major disadvantages [15]. In this study P 60 packable composite was used as the restorative material. The fillers of this composite included irregular particles, dust and colloidal silica and zirconia. The shrinkage is reduced during polymerization due to the shape of the fillers and particles as well as their size; as a result the microleakage is low in this composite [16].

In this work it was shown that the rate of microleakage in Open sandwich (RMGI) was significantly lower compared to Conventional method, and this result was consistent with the results of Hagge [7], and Anderson [17] studies. The reasons for high microleakage in Conventional method can be expressed as the following: In the gingival margins under CEJ, due to water content and the smear layer covering the dentinal tubules as well as the contraction force during polymerization of composite, these materials are unable to create maximum micro mechanical bond [18]. Moreover, high viscinity of packable composites, lead to less adaptation of the material to the walls, particularly in the gingival margins areas [19]. In addition, the newest bonding agents with 15-17 MPa strength bond are unable to cope with the contraction stresses completely and their qualities in the CEJ are questionable [20]. The RMGI can react chemically to enamel and dentin, and it can release the fluoride and reduce the recurrent caries. Furthermore, during polymerization the shrinkage of this material is low and the linear expansion coefficient of the material is close to the tooth structure. The resin contained in Fuji II LC and its hydrophilic feature is in a better adaptation with the walls of the tooth [21 & 22]. Beznos study was not consistent with this study [23]. Using RMGI is used as an intermediate material with low thickness or viscosity, the bond strength is reduced, and it is separated from the cavity floor followed by shrinkage resulted from composite polymerization, this can be the reason for detecting the high microleakage of this material in some studies [24].

The amount of marginal microleakage of Conventional method was significantly higher compared to Open Sandwich (Flowable), which is other result of the present study. The results of Leevailoj [9], Attar [10], Sadeghi [12], Yacizi [25] and Peutzfeldt [26] studies were similar to this study. Using a thin layer of the composite (about 1 mm thickness) can cause absorbing the shrinkage resulted from polymerization of composite above it, due to low elasticity modulus of flowable composite below the hybrid composite, and it acts as stress breaking, hence leads to reducing the marginal microleakage in restoration [27]. Furthermore, C factor is reduced (ratio of bonded surfaces to not bonded ones), hence the internal stress of composite being is reduced [28 & 29.

Flowable composites have lower viscosity, which leads to good adaptation with cavity floor in the proximal surface of the tooth under the packable composite, hence, the microleakage and tooth sensitivity after treatment are reduced [30]. In some studies [13, 14, 15], no considerable difference was found between conventional and open sandwich (Flowable) methods. In these studies, the reason was related to high strength of bonding agents to dentin [31]. Considering the higher polymerization shrinkage of flowable composites compared to hybrid composites, increasing the thickness to more than 1 mm can lead to increasing the marginal microleakage in the restoration of these materials [32]. This study showed that the amount of microleakage in snow plow method was significantly less compared to Conventional method. These results are confirmed in some studies including Chuang [32]. Similar to open sandwich (Flowable) more adaptation of flowable composite with cavity floor, reducing of voids, thinning of flow composite layer and the effect of C factor can reduce the marginal microleakage in this way. In the study of Yazici [25], higher microleakage in snow plow was observed compared to conventional method. It should be noted that the difference in preparing and restoration stages, are the reasons for different results. In this study no significant difference was found in the amount of microleakage between the open sandwich (RMGI) and open sandwich (Flowable). The studies of Majety [11] and Yazici [25] were similar to this study. In the study of Hagge [7] it was shown that microleakage in open sandwich method (RMGI) was significantly lower than open sandwich (Flowable). Polymerization shrinkage of flowable is increased by thickening, when they are used as intermediate material [32].

In this study, no significant difference was found between open sandwich (RMGI) and snow plow. Moreover, comparing open sandwich (Flowable) and snow plow in the rate of microleakage no significant difference was found. In some works, using snow plow method showed more microleakage compared to open sandwich (Flowable), which the reason is related to decreasing the bonding strength of the intermediate layer with the bottom of the cavity, which is associated to shrinkage during polymerization of hybrid composite when the intermediate layer and hybrid composite are cured simultaneously. On the other hand, when removing the instrument from the cavity, hybrid composite sticks to the instrument and then would lead to intermediate layer being pulled away from the bottom of the cavity [25].

CONCLUSION AND RECOMMENDATIONS:

The results showed that there is less microleakage in open sandwich with RMGI or flowable composite and Snow plow in which the intermediate material is used, compared to conventional restoration method. However, to choose the proper methods and materials to reduce or inhibit the marginal microleakage in the posterior restorations, more and more studies are essential.

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