Original Research

The Effect of a Glass Ceramic Insert in Sandwich Technique on Microleakage in Class II Composite Resin Restorations

Hila Hajizadeh[1], Saied Mostafa Moazzami[1], Nasrin Sarabi[1], Sara Majidinia[2]

[1] Dental Research Center and Department of Operative Dentistry, Faculty of Dentistry, Mashhad University of Medical Sciences, Mashhad, Iran

[2] Dental Materials Research Center and Department of Operative Dentistry, Faculty of Dentistry, Mashhad University of Medical Sciences, Mashhad, Iran

Received 10 January 2015and Accepted 12 February 2015

Abstract

Introduction: The aim of the present study was to evaluate the effect of glass ceramic insert in the sandwich technique to reduce microleakage in class II composite resin restorations. **Methods:** Sixty sound human upper second premolars were selected and randomly divided into six groups (n=10). Class II box-only cavities were prepared in distal aspects of each tooth with gingival margin located approximately 0.5 mm below the CEJ. Group A (Control) was restored incrementally with Tetric Ceram and a total-etch bonding technique. Group B and C were restored with sandwich technique using a compomer (Compoglass F) or flowable composite resin (Tetric Flow) as the lining material at gingival floor, respectively. Group D, E and F were represented in the same way as group A, B and C and a glass ceramic insert was added to the composite bulk. The specimens were thermo-mechanically cycled, and then immersed in 0.5 % basic fuschin for 24 hours. Dye penetration was detected using a sectioning technique. **Results:** No significant difference was found between total-etch bonding and sandwich techniques. The placement of an insert caused an increase in microleakage in all groups significantly ($P < 0.05$). Group D (no liner/ with glass insert) showed the highest amount of microleakage and Group A (no liner/ without glass insert) resulted in the lowest amount of total microleakage. **Conclusion:** Placement of glass ceramic insert could not decrease gingival leakage. According to the limitation of this study a composite resin restorations with incremental technique is recommended.

Key words: Microleakage, Posterior composite resin restoration, Sandwich technique, glass ceramic insert

----

Hajizadeh H, Moazzami SM, Sarabi N, Majidinia S. The Effect of a Glass Ceramic Insert in Sandwich Technique on Microleakage in Class II Composite Resin Restorations. J Dent Mater Tech 2015; 4(2): 57-64.

Introduction

Despite the improvement in the physical properties of composite resins, polymerization shrinkage still remains as a problem in direct restorations, which may affect marginal adaptation (1, 2). Shrinkage is a volume-dependent phenomenon (3). In an attempt to avoid problems, the use of prefabricated ceramic inserts with composite resins has been advocated for the esthetic and cost effective restoration of medium-sized class I and II cavities (4, 5).

Inserts are industrially produced using ceramic of various shapes, sizes, and colors. The insert technique is a dental restorative approach between direct composite restorations and the highly sophisticated, indirect ceramic inlay restoration. The combined advantages create a simple and cost-effective direct method for the esthetic restorations (6).

Besides the lower composite volume, ceramic inserts spreads the occlusal mastication forces over a larger surface. It also reduces peaks, and thus reduces the failure rate of direct composite restorations in the posterior region (7). Kunzelmann et al. (7) demonstrated using of finite element analysis that optimized inserts reduce the failure of posterior composite restorations caused by fatigue. They also showed that an anisotropic E-modulus of the insert minimizes the stress below the insert and its interface. Bowen (8) reported a 42% lesser formation of marginal gaps due to polymerization shrinkage with ceramic inserts with composite resin restorations.

Another approach to overcome shrinkage induced microleakage focuses on using a liner under posterior composite restoration. Some studies suggest the application of a flowable composite or compomers between the floor of the box and the restorative material as a sandwich technique (9, 10).

Flowable composite may exhibit a stress-reduction-by-flow property (9, 11). The use of compomer material is considered to simplify composite restoration as the same bonding system can be used for the compomer and composite material (12).

Studies pertaining the effect liner on microleackage have given controversial results. (13-17) The purposes of the present *in vitro* study were:

1- To evaluate the effect of glass ceramic insert and two different sandwich techniques using compomer or flowable composite in gingival microleakage below the CEJ in class II composite resin restorations.

2- To search if there is any difference in local microleakage between the lateral and medial areas of gingival floor.

Materials and Methods

Sixty freshly extracted sound human upper second premolars with similar size, stored in 0.2% sodium azide solution, were divided into six groups of 10 according to the type of lining material and the restoration technique (with or without the insert). Teeth were vertically embedded 2 mm below the CEJ in a cylindrical auto-polymerizing acrylic resin (Bosworth, Neocryl, USA). A box-only cavity was prepared in distal aspect of each tooth. The dimensions of the cavities were 4 mm buccolingual in width and 2 mm in depth at axiopulpal line angle. The gingival margin was located 0.5 mm below the CEJ with nearly 1.5 mm in depth. All preparations were performed with diamond fissure burs (# 878/d2, Teeskavan, Iran) in a high-speed handpiece with water spray. The burs were changed after every five cavity preparations. After cavity preparation, a Tofflemire matrix retainer and soft metal band were used. Then etchant (Ultra Etch, Ultradent, USA) and dentin bonding agent (Excite, Vivadent, Liechtenstein) was applied to the cavity walls according to the manufacturer's instructions. Each group was restored as described in table 1 and the text follows:

Group A (Control):

The cavity was restored with light cured composite resin (Tetric Ceram, Vivadent, Liechtenstein) using gingivocclusal incremental technique. While the first increment was 1 mm thick, the others were placed parallel to the gingival floor up to 2 mm in thickness. Each increment was light cured from occlusal aspect for 40 seconds by QTH light curing unit (UltraLux, DabiAtlante, Ribeirao Preto, SP, Brazil; light irradiance = 450 mW/cm^2). After the removal of the metal matrix, the restorations received further light curing from the buccal and lingual aspects, each for 40 seconds. The accuracy of light cure unit was monitored with a radiometer after each five restorations.

Group B:

A thin layer of a compomer (Compoglass F, Vivadent, Liechtenstein) with 1 mm thickness was placed, and light cured from the occlusal aspect for 40 seconds. The rest of the cavity was restored with a hybrid composite (Tetric Ceram) in the same way as group A.

Group C:

A thin layer of a flowable resin composite (Tetric Flow, Vivadent, Liechtenstein) with 1 mm thickness was placed, and light cured from the occlusal aspect for 40 seconds. The rest of the cavity was restored with a hybrid composite (Tetric Ceram) the same as group A.

Group D:

The entire cavity was restored with light cured composite resin (Tetric Ceram) using bulk technique. Right, after the composite placement over the cured bonding agent, a medium sized glass ceramic insert (SonicSys, Vivadent, Liechtenstein) was pressed into the composite at the middle of the restoration until firmly seated. After seating, the excess composite was removed and the remaining composite was adapted around the insert and against the cavity walls. Light cure was applied on the insert-composite restoration from occlusal aspect for 40 seconds. After the removal of the metal matrix, the restorations received further light curing from the buccal and lingual aspects, each for 40 seconds.

Group E:

A layer of a compomer (Compoglass F) with 1 mm thickness was placed on the gingival floor and the rest of the cavity was filled with hybrid composite (Tetric Ceram). The glass insert (SonicSys) was then pressed into the composite and the following steps were the same as group D.

Group F:

A layer of a flowable composite (Tetric Flow) with 1 mm thickness was placed on the gingival floor and the rest of the cavity was filled with hybrid composite (Tetric Ceram). After composite placement, the glass insert (SonicSys) was pressed into the composite and the following steps were the same as group D.

After 24 hours storing in 37°C and 100% humidity, all restorations were finished (Diamond finishing burs, Diamant, D&Z, Germany) and polished (Soft-lex polishing disks, 3M, USA). Then thermocycling was conducted at 5 and 55°C (± 4°C) bathes for 1,000 cycles. The immersion time for each bath and the interval between them was 30 seconds. Then load cycling was done with a load of 14 N, duration of 0.2 seconds and frequency of 3 Hz for 250,000 cycles. The teeth were then coated with two layers of nail varnish within 1 mm of the margins of the restorations and soaked in a solution of 0.5 % basic fuschin dye at 37°C incubators for 24 hours. The roots were cut off and the crowns were embedded in self- curing epoxy resin (Araldit CY219, Hardener HY5160, Ciba-Geigy, Switzerland). Two cuts were made in a mesio-distal direction 0.5 mm medially from the buccal and lingual margins of the restorations with a water cooled 1.0 mm thick diamond disc (Leitz 1600, Wetzlar, Germany). Therefore, two cuts per tooth provided three sections with four surfaces for gingival microleakage evaluation (Fig. 1).

Dye penetration was evaluated using a stereo-microscope (Blue Light Industry, USA) at x40 magnification. For each surface, the dye penetration at the gingival margin toward and along the gingival and axial walls was recorded separately in a tenth of a millimeter (10^{-1} mm). (Fig. 2) For statistical analysis, the data was categorized according to 4 scores (Table 2). Finally, data were analyzed with Kruskal-Wallis, Mann-Whitney and Friedman tests at $\alpha=0.05$.

Table 1. Experimental groups, material and the restorative procedures.

Group	Bonding System	Insert placement	Lining Material	Restorative Procedures	Restorative Material
A	Excite	No	No	*a, b, d*	Tetric Ceram
B	Excite	No	Compoglass F	*a, b, c, d*	Tetric Ceram
C	Excite	No	Tetric Flow	*a, b, c, d*	Tetric Ceram
D	Excite	Yes	No	*a, b, f,g*	Tetric Ceram
E	Excite	Yes	Compoglass F	*a, b, e, f, g*	Tetric Ceram
F	Excite	Yes	Tetric Flow	*a, b, e, f, g*	Tetric Ceram

Procedure Codes:
a: Enamel etched with 35% phosphoric acid for 30 seconds and dentinal surfaces were simultaneously etched with 35% phosphoric acid for 15 seconds, rinsed for 20 seconds, then air dried gently to keep dentin slightly moist.
b: Dentin bonding agent was applied according to manufacturer's instructions.
c: liner material was applied onto the cavity floor and was light cured according to manufacturer's instructions.
d: Composite resin was incrementally placed into the cavities, and each layer was light cured for 40 seconds.
e: liner material was applied onto the cavity floor
f: Composite resin was bulk placed into cavities
g: A glass ceramic insert, was pressed into the composite at the center of the restoration, and was light cured for 40 seconds

Table 2. Scoring the amount of microleakage

Amount of Microleakage	Score
0 mm	1
1-10 (10^{-1}mm)	2
10-20 (10^{-1}mm)	3
20< (10^{-1}mm)	4

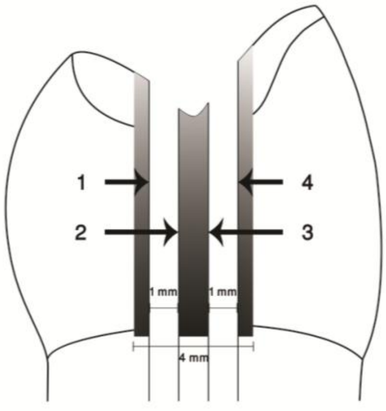

Figure 1. Schematic illustration of two sectioning cuts made four cut surfaces (1, 2, 3 and 4).

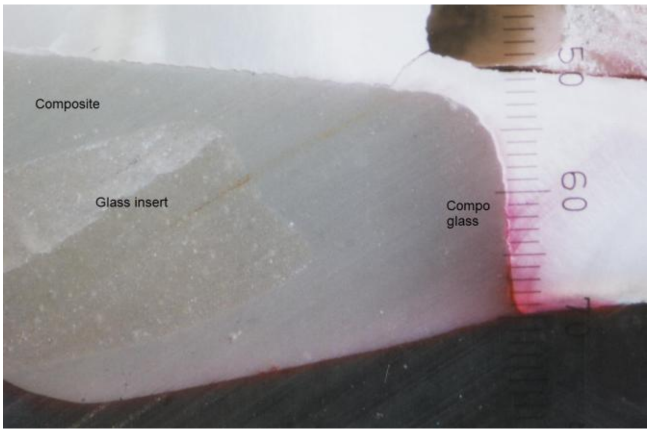

Figure 2. Dye penetration in one sample of group B (Compoglass F) at cut surface 2

Results

The results of dye penetration of each group are summarized in Table 3. All testing groups showed some degree of microleakage (Fig. 3). Group D (no liner/ with glass insert) showed the highest amount of microleakage (13.54) and Group A (no liner/ without glass insert) resulted in the lowest amount of total microleakage (6.07).

Insert placement significantly increased microleakage in all cut surfaces. In groups without insert (group A, B, C), there was no significant difference related to the kind of liner.

Group D which had no liner showed significantly more microleakage than the other groups with insert (group D, E, F) and there was a significant difference between groups D and E and no difference between groups E and F.

Friedman test were performed to detect any existing pattern of microleakage in gingival floor of different cut surfaces in each group. There was no significant difference in local microleakage between four cut surfaces of the restorations in each group (P>0.05). (Fig. 3, 4)

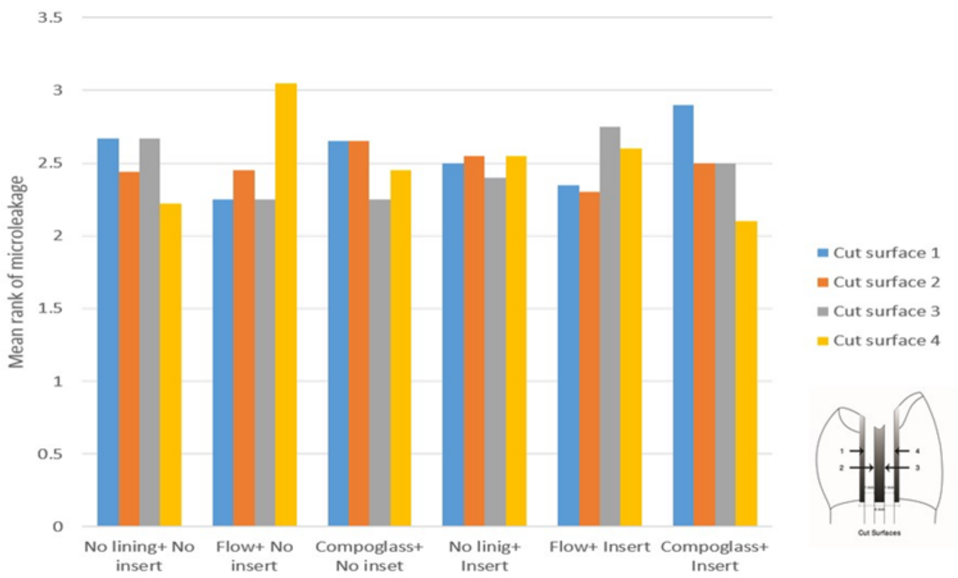

Fig 3. Mean Rank microleakage of each group in different cut surfaces

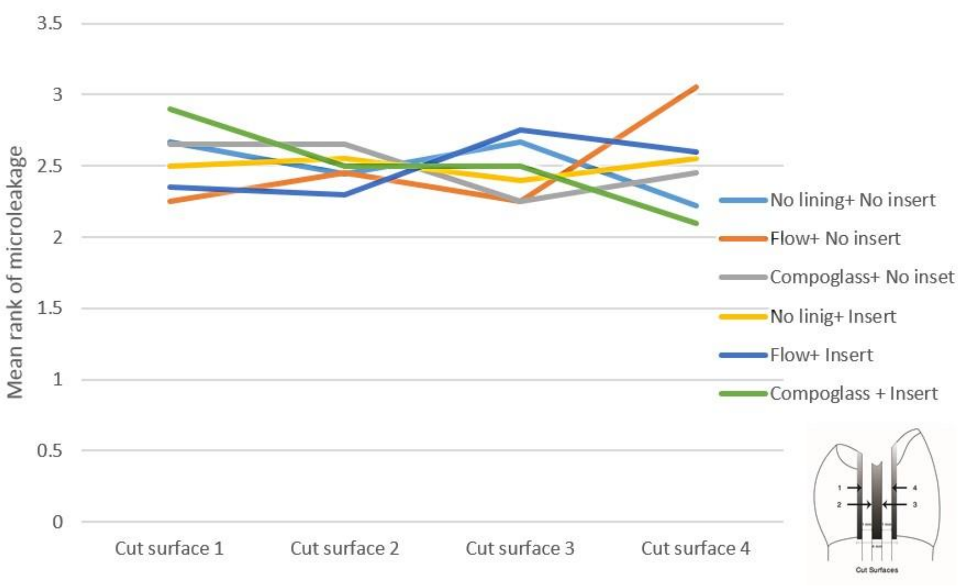

Fig 4. Mean rank microleakage of each cut surface in different groups

Table 3. Mean Rank of microleakage for testing groups

Group	Lining Material	N	Mean Rank*
A	No lining Material (Control)	10	6.07[a]
B	Tetric Flow	10	9.3 [a]
C	Compoglass F	10	8.32 [a]
D	No lining Material + glass insert	10	13.54 [b]
E	Tetric Flow + glass insert	10	11.7 [c]
F	Compoglass F + glass insert	10	12.7[c]

* Groups with different letters indicate statistical difference at Alpha = 0.05.

Discussion

Microleakage has been a major concern in operative dentistry. Some studies have reported that different methods of microleakage evaluation do not differ in the final results. Because of its long-term report in literature, the dye penetration method chosen in this study is a semi quantitative method. (18, 19)

According to Bowen et al. (20) study, inserts act as the so-called megafillers which allow the reduction in the composite volume by 50-70% and minimize polymerization shrinkage stresses and thus improve marginal adaptation of the restoration.

Several reports indicate that the use of a glass-ceramic insert reduces marginal gaps between the cavity wall and the composite material, (21) as well as microleakage of Class II and Class V composite restorations (22, 23). Others have indicated that in Class V cavities, the use of a ceramic insert is no better than a bulk placement technique, (24) while the present study showed that insert placement significantly increased microleakage in all cut surfaces in class II box-only composite restoration.

The use of the size-matched Sonicsys burs will reduce the area of exposed marginal composite. An alternative technique is to avoid using the Sonicsys-matched burs to shape the cavities. In this study, the preparation is carried out without the use of a matching device as recommended by the manufacturer. Bott and Hannig (5, 25) demonstrated that the insert shape should fit precisely . The restorations with the highest ceramic volume content had a significantly better marginal adaptation than those with less ceramic volume. There are no data suggesting a definite amount of resin volume that must be placed to reduce polymerization shrinkage stress and its related microleakage. (4)

Tjan et al and Strobel et al (23, 26) found no difference in marginal integrity of composite restorations with and without ceramic inserts. They said that ceramic materials do not bond to the composite resins chemically. They stated that although this truly seems that the reduction of resin composite volume means less shrinkage, placing a relatively large ceramic body into an uncured bulk of resin composite enlarges the configuration factor approximately five folds. This could explain why group D has a highest amount of microleakage compared to the other groups.

On the other hand the authors believe that these findings may be due to less degree of polymerization in the bottom of restoration under the insert with less light intensity.

For adequate wetting of the cavity walls, the use of a low-viscous flowable composite along with high-viscous composite resins has been advocated (lining technique).

In groups A, B and C (without insert), there was no significant difference regarding to the type of liners. Group A showed the least amounts of microleakage.

Previous studies indicated that the use of flowable composite as a liner in class II composite restorations reduced the gingival microleakage due to their composition and injectibility (9, 11, 27). In this study, microleakage of flowable composite-lined restorations without glass-ceramic insert (group B) was comparable to those of direct resin restorations which may be due to the liner thickness. Thicker flowable composite lining layer creates more polymerization shrinkage and marginal gaps. Chuang demonstrated that flowable composite is better to apply in a thin layer (11).

The use of compomer materials for sandwich restorations is proposed to reduce microleakage (28, 29, 30). In the present study, although there was no significant difference between groups without insert, the higher amounts of microleakage were observed in the compomer group.

Gale clearly demonstrated that microleakage is a three-dimensional phenomenon (31). Raskin et al performed a study in three different centers to test how the number of sections affected the maximum depth of tracer penetration and inspect the influence of the number of sections on reliability of in-vitro microleakage evaluations. They found out, regardless of the study center, that the correlation coefficient increased as a function of the number of sections up to three (32). Two cuts per restoration created four slabs of each restoration. this allowed to measure dye penetration at 4 locations in each specimen which made the result more reliable (33). As the results of this study showed, there was a significant difference in the cut surfaces of 2 and 3 between groups D (with insert and no liner) and E (with insert and flowable liner). These cut surfaces showed higher amount of microleakage in group D. As was stated earlier, the first layer in group E was cured before placing the composite and insert but in group D there was no curing of the first layer before placing the insert. Therefore the more leakage of the middle part of group D may be due to insufficient light penetration through the glass insert. There were also no significant differences between cut surfaces in the other groups.

It is suggested that a study be conducted for evaluating the survival of glass-ceramic insert restorations with mechanical loading.

Conclusion

Sandwich techniques with flowable composite (Tetric Flow) or a compomer (Compoglass F) could not decrease gingival microleakage. Total bond resin composite restoration with incremental technique is recommended.

Acknowledgment

This study was supported by a grant from Research Council of Mashhad University of Medical Sciences and Mashhad Dental Research Center, Mashhad, Iran.

References

1. Dietschi D, Dietschi JM. Current developments in composite materials and techniques. Pract Periodontics Aesthet Dent 1996;8:603-13; quiz 14.
2. Yap AU, Wang HB, Siow KS, Gan LM. Polymerization shrinkage of visible-light-cured composites. Oper Dent 2000;25:98-103.
3. Cheung GS. Reducing marginal leakage of posterior composite resin restorations: a review of clinical techniques. J Prosthet Dent 1990;63:286-8.
4. Federlin M, Thonemann B, Schmalz G. Inserts--megafillers in composite restorations: a literature review. Clin Oral Investig 2000;4:1-8.
5. Hahn P, Schaller HG, Mullner U, Hellwig E. Marginal leakage in class II-restorations after use of ceramic-inserts luted with different materials. J Oral Rehabil 1998;25:567-74.
6. Sjogren G, Hedlund SO, Jonsson C, Sandstrom A. A 3-year follow-up study of preformed beta-quartz glass-ceramic insert restorations. Quintessence Int 2000;31:25-31.
7. Kunzelmann KH OT, Mehl A, Hickel R Finite element analysis of megafillers/inserts to optimize shape and material properties. J Dent Res 1995; 74:187.
8. Bowen RL, George LA, Eichmiller FC, Misra DN. An esthetic glass-ceramic for use in composite restoration inserts. Dent Mater 1993;9:290-4.
9. Sadeghi M. The Effect of Fluid Composite as Gingival Layer on Microleakage of Class II Composite Restorations. Dental Research Journal 2007;4:40-7.
10. Fabianelli A, Sgarra A, Goracci C, Cantoro A, Pollington S, Ferrari M. Microleakage in class II restorations: open vs closed centripetal build-up technique. Oper Dent 2010; 35:308-13.
11. Chuang SF, Jin YT, Liu JK, Chang CH, Shieh DB. Influence of flowable composite lining thickness on Class II composite restorations. Oper Dent 2004;29: 301-8.
12. Xie H ZF, Wu Y, Chen C, Liu W. Dentine bond strength and microleakage of flowable composite, compomer and glass ionomer cement. Aust Dent J 2008;53: 325-31.
13. Araujo Fde O VL, Monteiro Junior S. Influence of resin composite shade and location of the gingival margin on the microleakage of posterior restorations. Oper Dent 2006; 31:556-61.
14. Bona AD, Pinzetta C, Rosa V. Effect of acid etching of glass ionomer cement surface on the microleakage of sandwich restorations. J Appl Oral Sci 2007;15:230-4.
15. Chuang SF LJ, Chao CC, Liao FP, Chen YH. Effects of flowable composite lining and operator experience on microleakage and internal voids in class II composite restorations. J Prosthet Dent 2001;85:177-83.
16. Koubi S, Raskin A, Dejou J, About I, Tassery H, Camps J, et al. Effect of dual cure composite as dentin substitute on marginal integrity of class II open-sandwich restorations. Oper Dent 2009;34: 150-6.
17. Opdam NJ, Bronkhorst EM, Roeters JM, Loomans BA. Longevity and reasons for failure of sandwich and total-etch posterior composite resin restorations. J Adhes Dent 2007;9:469-75.
18. Raskin A DHW, Gonthier S, Degrange M, Déjou J. Reliability of in vitro microleakage tests: a literature review. J Adhes Dent 2001;3:295-308.
19. Senawongse P, Pongprueksa P, Tagami J. The effect of the elastic modulus of low-viscosity resins on the microleakage of Class V resin composite restorations under occlusal loading. Dent Mater J 2010;29:324-9.
20. Bowen RL, Eichmiller FC, Marjenhoff WA. Glass-ceramic inserts anticipated for 'megafilled'

composite restorations. Research moves into the office. J Am Dent Assoc 1991;122:71, 3, 5.

21. Ozcan M, Pfeiffer P, Nergiz I. Marginal adaptation of ceramic inserts after cementation. Oper Dent 2002;27:132-6.
22. Olmez A ON, Bodur H. The effect of flowable resin composite on microleakage and internal voids in class II composite restorations. Oper Dent 2004;29:713-19.
23. Tjan AH, Dingman TA, Woolsey BL. Microleakage of posterior composite resin restorations using beta quartz glass-ceramic inserts. Asian J Aesthet Dent 1993;1:81-4.
24. Applequist EA, Meiers JC. Effect of bulk insertion, prepolymerized resin composite balls, and beta-quartz inserts on microleakage of Class V resin composite restorations. Quintessence Int 1996;27: 253-8.
25. Bott B, Hannig M. Optimizing Class II composite resin esthetic restorations by the use of ceramic inserts. J Esthet Dent 1995;7:110-7.
26. Strobel WO, Petschelt A, Kemmoona M, Frankenberger R. Ceramic inserts do not generally improve resin composite margins. J Oral Rehabil 2005;32:606-13.
27. Attar N, Turgut MD, Gungor HC. The effect of flowable resin composites as gingival increments on the microleakage of posterior resin composites. Oper Dent 2004;29:162-7.
28. Dietrich T LA, Lösche GM, Roulet JF. Marginal adaptation of direct composite and sandwich restorations in Class II cavities with cervical margins in dentine. J Dent 1999; 27:119-28.
29. Friedl KH, Schmalz G, Hiller KA, Mortazavi F. Marginal adaptation of composite restorations versus hybrid ionomer/composite sandwich restorations. Oper Dent 1997; 22:21-9.
30. Moazzami SM, Sarabi N, Hajizadeh H, Majidinia S, Li Y, Meharry MR, Shahrokh H. Efficacy of four lining materials in sandwich technique to reduce microleakage in class II composite resin restorations. Oper Dent 2014;39:256-63.
31. Gale MS, Darvell BW, Cheung GS. Three-dimensional reconstruction of microleakage pattern using a sequential grinding technique. J Dent 1994;22:370-5.
32. Raskin A, Tassery H, D'Hoore W, Gonthier S, Vreven J, Degrange M, et al. Influence of the number of sections on reliability of in vitro microleakage evaluations. Am J Dent 2003;16: 207-10.
33. Alani AH, Toh CG. Detection of microleakage around dental restorations: a review. Oper Dent 1997;22:173-85.

Corresponding Author:
Saied Mostafa Moazzami
Mashhad Dental School
Vakil-Abad Boulevard, Mashhad, IRAN
Tel: +98 511 8829501
Fax: +98 511 8829500
E-mail: MoazzamiM@mums.ac.ir