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Original Article

The effect of surface sealants with different filler content on microleakage of Class V resin composite restorations

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ABSTRACT

Objective: Microleakage is still one of the most cited reasons for failure of resin composite restorations. Alternative methods to prevent microleakage have been investigated increasingly. The aim of this study is to evaluate the microleakage in Class V resin composite restorations with or without application of surface sealants with different filler content. **Materials and Methods:** Ninety-six cavities were prepared on the buccal and lingual surfaces with the coronal margins located in enamel and the cervical margins located in dentin. The cavities restored with an adhesive system (Clearfil SE Bond, Kuraray, Tokyo, Japan) and resin composite (Clearfil Majesty ES-2, Kuraray, Tokyo, Japan). Teeth were stored in distilled water for 24 h and separated into four groups according to the surface sealants (Control, Fortify, Fortify Plus, and G-Coat Plus). The teeth were thermocycled (500 cycles, 5–55°C), immersed in basic fuchsine, sectioned, and analyzed for dye penetration using stereomicroscope. The data were submitted to statistical analysis by Kruskal–Wallis and Bonferroni–Dunn test. **Results:** The results of the study indicated that there was minimum leakage at the enamel margins of all groups. Bonferroni–Dunn tests revealed that Fortify and GC-Coat groups showed significantly less leakage than the Control group and the Fortify Plus group at dentin margins in lingual surfaces ($P < 0.05$). **Conclusion:** The all surface sealants used in this study eliminated microleakage at enamel margins. Moreover, unfilled or nanofilled surface sealants were the most effective in decreasing the degree of marginal microleakage at dentin margins. However, viscosity and penetrability of the sealants could be considered for sealing ability besides composition.

Key words: Microleakage, resin composite, surface sealant

INTRODUCTION

Today, advances in adhesive technology lead to an increase in the use of composite resin. Composite resins, especially preferred in the anterior region, are also used frequently as an alternative posterior restorative material depending on the increasing demand for esthetic restorations. However, despite advances in formulation of composite resins including different particle size, shape, and monomer type introduced with the aim of improving their physical and mechanical properties, microleakage is still seen as one of the most cited reasons for failure of resin composite restorations.[1]

Microleakage is defined as the penetration of various ions, liquids, microorganisms, and molecules between

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the restorative material and cavity walls. Factors causing microleakage include inadequate adhesion and thermal expansion coefficient differences between tooth and restorative material, polymerization shrinkage stress, and inadequate moisture control.[2-4] In addition, the main clinical signs associated with the microleakage are postoperative sensitivity, marginal discoloration, secondary caries, and pulpal inflammation.[2,4-6]

Various methods have been suggested to minimize the occurrence of microleakage at tooth/restoration interface in studies up to now.[7-13] Nowadays, a material named as restorative covering agents or surface sealants can be considered as an alternative for this purpose as well.[7,14] Surface sealants are polymerizable materials and contain enhanced formulations, including unfilled resins and other low molecular weight monomers (bisphenol-a glycidyl methacrylate, urethane dimethacrylate, and three ethylene glycol dimethacrylate) as well as extremely efficient photoinitiators and other modifiers.[1,7,14] Recently, filler particles were also added to some surface sealants to improve the mechanical properties.[1,15]

Surface sealants, applied over the cavosurface margins of the finished restorations, penetrate to the structural microdefects formed during finishing and polishing procedures and the marginal gaps by capillary action.[1,7,14,16] Hence, this effect can reduce microleakage by improving marginal sealing. *In vitro* studies have revealed that low viscosity, high flow rate, and high wettability properties are important requirements to provide the penetration (fluidity) onto material subsurface microstructure and good clinical performance for surface sealants.[1,7,14,17,18]

Beside these effects, low-viscosity surface sealants are used to increase the abrasion resistance and the integrity of the restoration by penetrating to the microgaps on restoration surface. Also, properties such as maintaining the color stability of the restoration by reducing plaque accumulation and preventing the adhesion of coloring pigments on composite restorations, facilitating the cleaning of the restoration by reducing surface roughness, and enhancing the brightness of the restoration can be considered as other advantages of surface sealants.[1,7,17,19,20]

There are some studies that examine the effects of these products on microleakage. As it is seen, inconsistent results about eliminating microleakage had been acquired from these studies. While some of these studies indicated that the application of surface sealants effectively decreased microleakage,[14,21-23] some of them reported that the application of surface sealants could not eliminate microleakage completely.[1,7,16] Consequently, it is recommended that further studies should be conducted to evaluate new materials and ensure the effects of these materials on microleakage with the aim of confirming the use of these materials in clinical routine. To the best of our knowledge, no information is available in the literature regarding the effect of surface sealants with different filler content on microleakage of resin restorations.

Therefore, the purpose of this study was to evaluate the marginal sealing ability of composite surface sealers including different filler content applied to Class V composite resin restorations, as well as comparing a control unsealed group. The null hypothesis was that the effect of surface sealants on microleakage would not differ according to the different filler content.

MATERIALS AND METHODS

Forty-eight extracted human mandibular third molars without caries, cracks, and fractures were used for this study. They were cleaned to remove calculus, soft tissue, and other debris using a periodontal scaling instrument. In each group, 24 Class V cavities were prepared on the buccal and lingual surfaces of the teeth with the coronal margins located in enamel and the cervical margins located in cementum (dentin). The cervical margins were located 1 mm apically to the cementoenamel junction level in dentin/cementum. The preparations were cut with a diamond bur in a high-speed handpiece cooled with an air-water spray. Cavity dimensions (3.0 mm in occlusogingival direction, 4.0 mm in mesiodistal direction, and 1.5 mm in depth) were measured with a periodontal probe to maintain standardization. No beveling was applied. One operator prepared all cavities to ensure a calibrated size and depth. After five preparations, the used bur was discarded and a new one was selected. After cavity preparation, a two-step self-etch adhesive system (Clearfil SE Bond, Kuraray, Tokyo, Japan) was applied to all cavities according to the manufacturers' instructions [Table 1]. Primer was applied to the entire cavity wall and was left for 20 s. After conditioning the tooth surface 20 s, the cavity was exposed to a mild oil-free air stream. Following the primer procedures, bond was applied to the entire surface of the cavity obtaining the bond film as uniform as possible using a gentle oil-free air stream. The tooth surfaces were polymerized with a conventional halogen light-curing unit (Demetron

Table 1: The materials used in the study

Material	Manufacturer/Lot	Component (manufacturer MSDS)	Application procedure
Fortify (unfilled surface sealant)	Bisco, Schaumburg, USA/1400007570	UDMA	Etch the entire surface of the restoration for 20 s; rinse and air dry. Apply one thin layer of Fortify and gently air dry, light cure for 10 s
Fortify Plus (microfilled surface sealant)	Bisco, Schaumburg, USA/150000092	UDMA, amorphous silica	Etch the entire surface of the restoration for 20 s, rinse and air dry. Apply one thin layer of Fortify Plus and gently air dry, light cure for 10 s
G-Coat Plus (Nanofilled surface sealant)	GC, Tokyo, Japan/1202131	Urethane methacrylate, methylmethacrylate, camphorquinone, silicon dioxide, phosphoric ester monomer	Apply one coat of G-Coat Plus and light cure for 20 s
Clearfil SE BOND	Kuraray, Tokyo, Japan/350078-360125	Primer: MDP, HEMA, hydrophilic aliphatic dimethacrylate, di-Camphorquinone, N, N-diethanol-p-toluidine, water Bond: MDP, Bis-GMA, HEMA, hydrophobic aliphatic dimethacrylate, di-camphorquinone, N, N-diethanol-p-toluidine, colloidal silica	Apply primer to entire surface and leave for 20 s Air dry for 5 s Apply bond Air-flow gently Light cure for 10 s
Clearfil Majesty ES-2	Kuraray, Tokyo, Japan/00006A	Silanated barium glass filler, prepolymerized organic filler, Bis-GMA, hydrophobic aromatic dimethacrylate, di-camphorquinone	Apply in 1.5 mm increments Light cure for 40 s

UDMA: Urethane dimethacrylate, MDP: 10-Methacryloyloxydecyl dihydrogen phosphate, HEMA: 2-hydroxyethyl methacrylate, Bis-GMA: Bisphenol A diglycidylmethacrylate, MSDS: Material safety data sheets

LC, Kerr, Orange, CA, USA) for 20 s. The composite resin (Clearfil Majesty ES-2, Kuraray, Tokyo, Japan) was inserted in a single increment and light cured for 40 s (Demetron LC, Kerr, Orange, CA, USA). Following restorations, all teeth were stored in distilled water at 37°C for 24 h before finishing/polishing and application of surface covering. The restorations were then finished/polished with Sof-Lex (3M-ESPE, St. Paul, MN, USA) flexible aluminum oxide disks of decreasing abrasiveness (coarse to superfine).

The specimens were randomly assigned to four groups with 12 teeth each according to different surface sealers applied: Fortify (Bisco) group, Fortify Plus (Bisco) group, G-Coat Plus group (GC), and Control group. The composite surface sealers used are listed in Table 1. All covering agents were applied according to the manufacturer's recommendations.

Group 1 (Fortify)
The entire surface of the restoration and approximately 1–2 mm beyond the tooth/restoration margin were conditioned with 37% phosphoric acid for 20 s, followed by rinsing with copious amounts of water and drying. One thin coat of Fortify was applied to the restoration/tooth surfaces, gently air-thinned, and light cured for 10 s.

Group 2 (Fortify Plus)
The entire surface of the restoration and approximately 1–2 mm beyond the tooth/restoration margin were conditioned with 37% phosphoric acid for 20 s, followed by rinsing with copious amounts of water and drying. One thin layer of Fortify Plus was applied to the restoration/tooth surfaces, gently air-thinned, and light cured for 10 s

Group 3 (G-Coat Plus)
One coat of G-Coat was applied to the restoration/tooth surfaces and light cured for 20 s.

Group 4 (Control)
Control group received no surface protection material.

The restored teeth were subjected to artificial aging by thermocycling. All specimens were immersed in water baths at 5°C and 55°C for 500 cycles, with a dwell time of 30 s in each bath and a transfer time of 10 s. The root apices were sealed with acrylic resin, and two coats of nail varnish were applied to the entire tooth surface, leaving a 1.0-mm window around the restoration margins. The teeth were then immersed in a 0.5% basic fuchsine solution (Merck KGaA, Darmstadt, Germany) for 24 h at room temperature. The teeth were rinsed under tap water and air dried. The nail varnish was removed and the roots of the teeth were embedded in an acrylic resin. Afterward, the specimens were sectioned longitudinally through the center of the restoration in buccolingual direction with a water-cooled low-speed precision cutter (Micracut 125, Metkon, Bursa, Turkey) and diamond saw (Dimos, Metkon, Bursa, Turkey). Two sections were obtained from each restoration.

Each section was examined at ×20 magnification using a stereomicroscope (S4E, Leica Microsystems, Wetzlar, Germany) by two previously calibrated independent evaluators separately under the same conditions (light, temperature, and localization). The evaluators were instructed about the evaluation criteria before observation. If there were disagreements in scores, consensus was obtained between evaluators. Photographs were taken from each section with a camera of stereomicroscope (D-Lux 3, Leica, Wetzlar, Germany). The degree of leakage was determined as follows:[1,14]

- 0 = No dye penetration
- 1 = Dye penetration up to one-half of the extension of the cavity wall
- 2 = Dye penetration greater than one-half of the extension of the cavity wall, not including the axial surface
- 3 = Dye penetration greater than one-half of the extension of the cavity wall, including the axial surface.

Statistical analysis

Statistical analysis of the results at the coronal (enamel) and gingival (dentin) margins separately among the treatment groups was performed with nonparametric test method, using the Kruskal–Wallis test.

One of the multiple comparison methods, Bonferroni–Dunn, was used to determine the difference between the average ranks of groups. All statistical tests were performed at a $P < 0.05$ level of significance.

RESULTS

Microleakage scores between the groups at the enamel margins were analyzed separately for the buccal and lingual surfaces. While the leakage was observed only in one tooth in Control group, there was no dye penetration in the first three groups in the lingual surface. A statistical assessment could not be done due to the absence of microleakage in the three groups. In buccal surface, there was no dye penetration at both the GC-Coat Plus and Control groups. Moreover, in Fortify and Fortify Plus groups, the leakage was observed only in one tooth. Also, a statistical evaluation could not be done in this case because there is no leakage in the two groups. Table 2 lists the distribution of microleakage scores at the coronal and gingival margin locations in each surface.

At the gingival margins, none of the studied groups were capable to completely eliminating marginal microleakage. Microleakage scores between the groups at the dentin margins were evaluated separately in terms of buccal and lingual surfaces as well. The differences between the average ranks of the groups, obtained by the Kruskal–Wallis test, were examined. Statistical analysis (Kruskal–Wallis) revealed significant differences ($P < 0.05$) between the groups at gingival margins in lingual surface. The results of comparison of the groups performed with Bonferroni–Dunn test are shown in Table 3. Fortify and GC-Coat Plus groups showed significantly less leakage than the Control group and the Fortify Plus group [$P < 0.05$, Table 3].

There were differences between the groups at gingival margin in buccal surfaces but the differences between the average ranks of groups were not statistically significant ($P > 0.05$, Kruskal–Wallis).

DISCUSSION

The results of this study showed that all surface sealants tested produced the similar results at enamel margins, but dentin margins demonstrated different

Table 2: The distribution of microleakage scores at the coronal and gingival margin locations in each surface

Materials	0		1		2		3		n
	Coronal	Gingival	Coronal	Gingival	Coronal	Gingival	Coronal	Gingival	
Fortify									
Buccal	23	20	1	0	0	0	0	4	24
Lingual	24	20	0	1	0	0	0	3	
Fortify Plus									
Buccal	23	13	1	3	0	0	0	8	24
Lingual	24	13	0	1	0	1	0	9	
GC-Coat Plus									
Buccal	24	20	0	0	0	0	0	4	24
Lingual	24	20	0	2	0	0	0	2	
Control									
Buccal	24	15	0	0	0	0	0	9	24
Lingual	23	14	1	1	0	0	0	9	

Table 3: Results of the statistical analysis at gingival margins in lingual surface

Group	*n*	Median	Average rank	*P*
1	24	0.000000000	41.9[b]	
2	24	0.000000000	56.3[a]	0.026
3	24	0.000000000	41.3[b]	
4	24	0.000000000	54.6[a]	

*Values followed by different alphabets (in superscript) differ among the others by Kruskal–Wallis and Dunn tests ($P<0.05$)

leakage patterns according to different types of sealant material. Thus the null hypothesis was rejected.

In restorative dentistry, microleakage due to the deterioration of marginal adaptation has been reported to be one of the main reasons for restorations failure. An optimal marginal seal is an essential factor for the longevity of the restorations.[8] Therefore, the present study investigated different surface sealants effectiveness on the marginal seal of the Class V restorations.

Microleakage tests are useful methods for evaluating the sealing ability of the materials.[24-27] Among different methods employed, dye penetration method can be seen as the most commonly used method due to ease of application and reliable results.[25,27,28] Also, this method may determine the predicted performance of materials and the extension of marginal gaps toward the axial wall of the restorations.[24-27]

In theory, composite surface sealants have been proposed to improve the marginal integrity of a composite resin restoration and to minimize or prevent the microleakage. The application of a low-viscosity resin over the margins of a restoration could penetrate deeply into microgaps as well into surface microdefects.[14,16,18] However, to be effective and satisfactory, the surface sealants must present good wetting properties, low contact angle, the viscosity to flow into small defects of the restoration, and the surface tension be equal to or less than the critical surface tension of the restoration/tooth structure.[7,14,16]

In the present study, to improve the effectiveness of surface sealants and decrease the formation of microgaps, restorations were polished before coating application but not immediately after restoration. Restorations were subjected to delayed polishing procedure. Irie *et al*. reported that the immediate polishing of composite Class V restorations resulted in an increase of interfacial gaps compared to delayed polishing.[29] Also, according to Magni *et al*., the immediate removal of excess of restorative material at the restoration margins through polishing could result in the increase of marginal gaps, which are subsequently infiltrated and filled by the coating material, thus explaining the significant improvement of the marginal seal observed in the polished groups after coating.[8]

In this study, different materials were chosen to evaluate how their composition and physical characteristics influenced the fluidity and penetrability, thus preventing microleakage. The results of this study showed that none of the materials tested were completely resistant to dye penetration (leakage) at the dentin margins. This result was expected due to the complex nature of dentin and was in agreement with the similar studies, whereby decreased permeability and increased sealing ability was observed at the enamel margins.[1,14,16] It was found that the groups treated with Fortify and G-Coat Plus presented the lowest degree of microleakage while the control (without treatment) group and the group treated with Fortify Plus presented the highest microleakage scores at the dentin margins. In general, Fortify and Fortify Plus have the same application procedure and both groups were subjected to etching treatment. Different opinions were reported about the effect of acid etching treatment on the microgaps and the formation of microleakage in literature. It was reported that the existing microdefects and microgaps filled with composite resin smear during finishing procedures may be exposed partially by the etching procedure.[13,16] On the other hand, in some studies, it has been demonstrated that etched, clean, and dry surface demonstrates an ideal environment for penetration of surface sealants into the marginal gap and favorable wetting properties by permitting achievement of higher levels of critical surface tensions.[7,14] In accordance with these results, it can be concluded that acid etching might be performed positive impact on sealing ability of surface sealant. However, keep in mind that viscosity of the materials is another important factor effecting penetrability, wettability, and sealing properties. In addition, sealants and bonding agents can contain filler particles and opaquers that decrease fluidity of the material with a reduction in wettability of the prepared surfaces.[14] It is considered that Fortify Plus can be inadequate on the sealing ability by reduced viscosity and fluidity due to microsized filler composition according to Fortify.

In a study by dos Santos *et al*., assessing the effects of surface sealants and dentin adhesive systems on microleakage, similar results with our study were observed. They found that Fortify presented lower microleakage values than Fortify Plus and adhesive systems.[21] However, there were also many other microleakage studies reporting a better seal produced by Fortify compared to other low-viscosity resins and adhesive systems.[22,23,30]

Due to the composition of the materials used in this study, it might have been expected that the nanofilled surface sealant might have shown less leakage compared to the microfilled surface sealant. However, possible reasons for the reduced microleakage values associated with the G-Coat Plus may be more effective than Fortify Plus about sealing of microgaps due to including a nanosized filler particle in its resin matrix formula. In a microleakage study, evaluating the effect of protective coating on marginal integrity of nanohybrid composite during bleaching with carbamide peroxide, it was determined that the amount of microleakage due to carbamide peroxide bleaching in tooth without coating is more when compared with bleaching done with the application of G-Coat Plus. Similar to our study, significant reduction in microleakage was seen in groups with G-Coat Plus when compared to other groups.[31]

CONCLUSION

Within the limitations of our study, it can be stated that the sealing effect of a surface sealants on microleakage would differ according to the variation in composition and viscosity of the used materials. All surface sealants used in this study eliminated microleakage at enamel margins. Moreover, unfilled or nanofilled surface sealants were the most effective in decreasing the degree of marginal microleakage at dentin margins. Consequently, unfilled or nanofilled surface sealants may be preferred to diminish microleakage for clinicians.

Although *in vitro* studies provide less reliable evidence than *in vivo* studies, these microleakage studies can be used as a part of an *in vitro* preassesment of new materials. Also, further clinical studies should be performed to determine the longevity of sealing ability of these materials.

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Conflicts of interest
There are no conflicts of interest.

REFERENCES

1. Sadeghi M, Davari A, Lynch CD. The effect of re-bonding using surface sealant or adhesive system on microleakage of class V resin composite restorations. Dent Res J (Isfahan) 2013;10:596-601.
2. Arora R, Kapur R, Sibal N, Juneja S. Evaluation of Microleakage in class II cavities using packable composite restorations with and without use of liners. Int J Clin Pediatr Dent 2012;5:178-84.
3. Lokhande NA, Padmai AS, Rathore VP, Shingane S, Jayashankar DN, Sharma U. Effectiveness of flowable resin composite in reducing microleakage – An *in vitro* study. J Int Oral Health 2014;6:111-4.
4. Kasraie S, Azarsina M, Khamverdi Z, Shokraneh F. Microleakage of dual-cured adhesive systems in class v composite resin restorations. J Dent (Tehran) 2012;9:99-106.
5. Sánchez-Ayala A, Farias-Neto A, Vilanova LS, Gomes JC, Gomes OM. Marginal microleakage of class V resin-based composite restorations bonded with six one-step self-etch systems. Braz Oral Res 2013;27:225-30.
6. Arias VG, Campos IT, Pimenta LA. Microleakage study of three adhesive systems. Braz Dent J 2004;15:194-8.
7. D'Alpino PH, Pereira JC, Rueggeberg FA, Svizero NR, Miyake K, Pashley DH. Efficacy of composite surface sealers in sealing cavosurface marginal gaps. J Dent 2006;34:252-9.
8. Magni E, Zhang L, Hickel R, Bossù M, Polimeni A, Ferrari M. SEM and microleakage evaluation of the marginal integrity of two types of class V restorations with or without the use of a light-curable coating material and of polishing. J Dent 2008;36:885-91.
9. Atoui JA, Chinelatti MA, Palma-Dibb RG, Corona SA. Microleakage in conservative cavities varying the preparation method and surface treatment. J Appl Oral Sci 2010;18:421-5.
10. Ghavamnasiri M, Moosavi H, Tahvildarnejad N. Effect of centripetal and incremental methods in Class II composite resin restorations on gingival microleakage. J Contemp Dent Pract 2007;8:113-20.
11. Sensi LG, Marson FC, Baratieri LN, Monteiro Junior S. Effect of placement techniques on the marginal adaptation of class V composite restorations. J Contemp Dent Pract 2005;6:17-25.
12. Costa Pfeifer CS, Braga RR, Cardoso PE. Influence of cavity dimensions, insertion technique and adhesive system on microleakage of class V restorations. J Am Dent Assoc 2006;137:197-202.
13. Demirci M, Tuncer S, Tekce N, Erdilek D, Uysal O. Influence of adhesive application methods and rebonding agent application on sealing effectiveness of all-in-one self-etching adhesives. J Esthet Restor Dent 2013;25:326-43.
14. Owens BM, Johnson WW. Effect of new generation surface sealants on the marginal permeability of class V resin composite restorations. Oper Dent 2006;31:481-8.
15. Lopes MB, Saquy PC, Moura SK, Wang L, Graciano FM, Correr Sobrinho L, *et al.* Effect of different surface penetrating sealants on the roughness of a nanofiller composite resin. Braz Dent J 2012;23:692-7.
16. Delfino CS, Duarte S Jr. Effect of the composite surface sealant application moment on marginal sealing of compactable composite resin restoration. J Mater Sci Mater Med 2007;18:2257-61.
17. Antonson SA, Yazici AR, Okte Z, Villalta P, Antonson DE, Hardigan PC. Effect of resealing on microleakage of resin composite restorations in relationship to margin design and composite type. Eur J Dent 2012;6:389-95.
18. Silva Santana SV, Bombana AC, Flório FM, Basting RT. Effect of surface sealants on marginal microleakage in class V resin composite restorations. J Esthet Restor Dent 2009;21:397-404.
19. Aguilar FG, Roberti Garcia Lda F, Cruvinel DR, Sousa AB, de Carvalho Panzeri Pires-de-Souza F. Color and opacity of composites protected with surface sealants and submitted to artificial accelerated aging. Eur J Dent 2012;6:24-33.
20. Valentini F, Oliveira SG, Guimarães GZ, Barbosa RP, Moraes RR. Effect of surface sealant on the color stability of composite resin restorations. Braz Dent J 2011;22:365-8.
21. dos Santos PH, Pavan S, Assunção WG, Consani S, Correr-Sobrinho L, Sinhoreti MA. Influence of surface sealants on microleakage of composite resin restorations. J Dent Child (Chic) 2008;75:24-8.
22. Lima AF, Soares GP, Vasconcellos PH, Ambrosano GM, Marchi GM, Lovadino JR, *et al.* Effect of surface sealants on microleakage of Class II restorations after thermocycling and long-term water storage. J Adhes Dent 2011;13:249-54.

23. Ramos RP, Chinelatti MA, Chimello DT, Dibb RG. Assessing microleakage in resin composite restorations rebonded with a surface sealant and three low-viscosity resin systems. Quintessence Int 2002;33:450-6.
24. Celik C, Cehreli SB, Arhun N. Resin composite repair: Quantitative microleakage evaluation of resin-resin and resin-tooth interfaces with different surface treatments. Eur J Dent 2015;9:92-9.
25. Idriss S, Abduljabbar T, Habib C, Omar R. Factors associated with microleakage in class II resin composite restorations. Oper Dent 2007;32:60-6.
26. Ernst CP, Galler P, Willershausen B, Haller B. Marginal integrity of class V restorations: SEM versus dye penetration. Dent Mater 2008;24:319-27.
27. Heintze S, Forjanic M, Cavalleri A. Microleakage of class II restorations with different tracers – Comparison with SEM quantitative analysis. J Adhes Dent 2008;10:259-67.
28. Amaral CM, Peris AR, Ambrosano GM, Pimenta LA. Microleakage and gap formation of resin composite restorations polymerized with different techniques. Am J Dent 2004;17:156-60.
29. Irie M, Tjandrawinata R, Suzuki K. Effect of delayed polishing periods on interfacial gap formation of class V restorations. Oper Dent 2003;28:552-9.
30. Ramos RP, Chimello DT, Chinelatti MA, Dibb RG, Mondelli J. Effect of three surface sealants on marginal sealing of class V composite resin restorations. Oper Dent 2000;25:448-53.
31. Kumar AA, Hariharavel VP, Narayanan A, Murali S. Effect of protective coating on marginal integrity of nanohybrid composite during bleaching with carbamide peroxide: A microleakage study. Indian J Dent Res 2015;26:167-9.