©Operative Dentistry, 2016, **41-3,** 268-275

Clinical Performance of Composite Restorations with Resin-modified Glass Ionomer Lining in Root Surface Carious Lesions

U Koc Vural • S Gökalp • A Kiremitci

Clinical Relevance

The application of cavity lining material did not affect clinical performance, particularly marginal adaptation rate, over an 18-month period.

SUMMARY

Objective: The purpose of this study was to evaluate the clinical performance of composite restorations in root surface carious lesions with or without resin-modified glass ionomer lining.

Methods and Materials: The sample consisted of 25 female and 14 male patients. A maximum of four lesions were included for each patient. After caries removal, the depth, length, and width of the cavity were measured. Lesions in the same patient were randomly divided into two groups, and the dentin surfaces were either lined with resin-modified glass ionomer liner (Glass Liner II) or left as they were. Self-etch adhesive (All Bond SE) was applied and cured for 20 seconds. All cavities were restored with nanohybrid anterior composite resin (Clearfil Majesty Esthetic). Two experienced clinicians evaluated the marginal adaptation (retention) rate, anatomic form, secondary caries, sensitivity, and marginal staining of restorations at the end of the first week and at six, 12, and 18 months posttreatment. The data were statistically analyzed using the Chi-square and two-way repeated measures tests.

Results: At the end of 18 months, a total of five lined and three unlined restorations were lost. There was no significant relationship between marginal adaptation and cavity lining at six, 12, and 18 months ($p>0.05$). Although marginal stainings of restorations were mostly localized, the total number of localized or generalized discolored restorations increased with time ($p<0.001$). There was a statistically significant relationship between marginal staining and smoking ($p>0.05$). There was no significant relationship between marginal staining and frequency of toothbrushing at six, 12, and 18

*Uzay Koc Vural, DDS, PhD, Department of Restorative Dentistry, Hacettepe University, Altindag, Ankara, Turkey

Saadet Gökalp, DDS, PhD, Department of Restorative Dentistry, Hacettepe University, Altindag, Ankara, Turkey

Arlin Kiremitci, DDS, PhD, Department of Restorative Dentistry, Hacettepe University, Altindag, Ankara, Turkey

*Corresponding author: Altındag, Ankara 06100, Turkey; e-mail: uzaykoc@gmail.com

DOI: 10.2341/15-205-C

months (p=0.286, p=0.098, and p=0.408, respectively).

Conclusion: Within the limitations of this study, both restorative applications were accepted as clinically appropriate.

INTRODUCTION

The etiology of root surface caries is multifactorial, with microbiological factors playing a critical role. The cervical margins of root surface carious lesions are usually located in the cementum or dentin, making it more susceptible to bacterial invasion (microleakage). Microleakage can lead to problems such as marginal staining, secondary caries, and pulpal inflammation.[1] The pulp requires protection from further bacterial invasion of the carious process and chemical protection from the overlying restorative materials.[2] This may be achieved by placement of a biocompatible liner on the cavity floor.[3] Lining with resin-modified glass ionomers (RMGICs) has been shown to lead to clinical success and also to promote a dramatic reduction in the number of cariogenic bacteria.[4] Resilient liners, such as RMGICs, are capable of absorbing the polymerization contraction stress of the overlying resin composites.[5,6] Contraction stress is one of the main causes of microleakage and often leads to postoperative sensitivity, marginal staining, and secondary caries.[5,6] An *in vitro* study[7] reported the lowest percentage of marginal gap with RMGIC liners.

Materials such as resin composites are widely used for the restoration of root surface caries as they do not require excessive removal of sound tooth structure and have a low modulus of elasticity. Self-etching adhesives are often used for bonding of composite restorations of root surface caries as they are easy to manipulate. On the other hand, some authors[8,9] reported that application of adhesives in deep cavities resulted in acceptable levels of biocompatibility. However, the intensity of the pulpal response depended upon the thickness of the remaining dentin. These views motivated clinicians to reevaluate the use of liners and adhesives.

The aim of this randomized, controlled clinical trial was to evaluate the clinical performance of a nanohybrid composite resin restoration in carious root surface lesions lined with and without a RMGIC liner. The cavity size, toothbrushing, and smoking habits of patients were also included as additional observations.The null hypothesis tested was that there is no difference between the two restorative systems with respect to marginal adaptation (retention), marginal staining, secondary caries, and postoperative sensitivity.

METHODS AND MATERIALS

Thirty-nine nonhospitalized volunteer patients who presented with root surface carious lesions at the Restorative Dental Clinic were randomly selected for this study. Their ages ranged between 18 and 67 years, with the mean age being 39.62 ± 13.85 years.

The local institutional review board approved this clinical trial prior to commencement. The volunteers were informed about the conditions and objectives of the study and were asked to provide informed consent.

A paired-tooth design was used for this study. Patients who were under the age of 18 years or who had complex medical histories, severe or chronic periodontitis, extreme carious activity, heavy bruxism, very deep or superficial carious lesions, or previously restored and abutment teeth were excluded from the study. Lesions were classified as inactive if their surface was leathery, shiny, or not covered with plaque.

A single operator carried out all restorative procedures, and the lesion surface was pumiced before the intervention. Moisture control was carried out with the help of cotton rolls and a saliva ejector. Cavity preparation was completed with a diamond bur, and the carious lesion was removed with the help of a steel bur. The enamel margins were beveled but no mechanical retention was performed. The depth, width, and length of the cavity were measured and recorded by two experienced and calibrated clinicians using a periodontal (WHO 973/80-Martin, Solingen, Germany) explorer. In each patient, two or four root surface carious lesions were randomly restored according to two experimental protocols. A coin was tossed and depending on the outcome cavities were either lined or left as they were. The liner was placed and light-cured for 20 seconds and the enamel walls were not sealed with the lining material. Thereafter, two separate coats of All Bond SE (one-step self-etch adhesive) were applied using a microbrush for 15 seconds per coat (no light-cure between coats) for all cavities, air-dried for at least 10 seconds, and then LED light-cured for 10 seconds (Led Max 5; Hilux, Benlioglu Dental, Ankara, Turkey) set at 500-700 mW/cm^2 intensity. The materials used in this study are presented in Table 1.

Both groups were restored with the nanohybrid composite (Clearfil Majesty Esthetic) using the

Table 1: *Description of the Materials Used in this Study*

Materials	Composition	Manufacturer	Batch No.
All bond SE	Part I—ethanol, sodium benzene sulfinate dehydrate Part II—Bis (glyceryl 1,3 dimethacrylate)–phosphate; hydroxyethyl methacrylate biphenyl dimethacrylate	Bisco Inc, Schaumburg IL, USA	0900004181 0900004182
Glass Liner II	Liquid: polycarbonic acid-water Powder: calcium-aluminum-fluoro-silicate, barium glass	WP Dental, Barmstedt, Germany	120298
ClearfıI Majesty Esthetic	Matrix: Bis-GMA, hydrophobicaromatic dimethacrylates, and hydrophobicaliphatic dimethacrylates, DL-camphorquinone	Kuraray, Tokyo, Japan	00014C

Abbreviation: Bis-GMA, bisphenol A diglycidyl ether dimethacryalate.

incremental technique with a flat-faced condenser. Each resin composite layer was light-cured for 20 seconds with the same LED light-curing unit. All restorations were finished with extra-/ultrafine composite finishing burs (Diatech Dental AC, Heerbrugg, Switzerland) and polished with discs (SwissFlex; Diatech Dental AC) and Enhance PoGo Complete Kit (Dentsply, Addlestone, York, PA, USA).

A double-blind study design was used, and two calibrated clinicians (other than the operator) evaluated all restorations. Direct intraoral clinical examination was carried out by two calibrated examiners. The quality of the restorations was evaluated according to marginal adaptation (retention), anatomical form, caries in adjacent tooth structure, and caries at the cavosurface margin (Table 2). The criteria developed by Haveman and others[10] were modified by adding sensitivity and marginal staining scores.

The sensitivity score was based on the subjective symptoms of the patient to cold air (yes/no), while staining of restorations was determined visually as being localized/generalized. Marginal staining was defined as localized if there was discoloration on less than half of the circumferential margin or defined as generalized if there was discoloration on more than half of the circumferential margin.[11]

The width, length, and depth (in millimeters) of the cavities were grouped before statistical analysis. Toothbrushing frequencies were identified as once or twice a day. Smokers were also divided into the following three groups: nonsmoker, 1-10 cigarettes per day, and more than 10 cigarettes per day.

Restorations were evaluated at baseline and again at six, 12, and 18 months posttreatment. The baseline rating was carried out one week posttreatment. Chlorhexidine (Kloroben, Drogsan, Turkey) mouth-rinse was prescribed for five days, and standard toothpaste (Colgate Total; 1450 ppm sodium fluoride [NaF] 0.3% triclosan/copolymer/ 0.22% NaF) was advised for daily use.

Table 2: *Evaluation Criteria (1)*

Score	Marginal Adaptation (Retention)
0	The restoration appears to adapt closely to the surface of the tooth with no crevice formation. An explorer either did not catch when drawn along the margin or only did so when passed in one direction.
1	An explorer caught lightly when run in both directions, and there was visible evidence of early crevice formation. Dentin was not visible.
2	An explorer got caught in both directions and penetrated a marginal crevice. There was visible evidence of crevice formation. However, the dentin was not visible.
3	The crevice had sufficient depth to expose the dentin. The restoration required replacement.
4	The restoration was fractured or lost.
	Anatomical Form
0	The restoration was continuous with the existing tooth anatomy.
1	The restoration was not continuous with the existing tooth anatomy, but no dentin was exposed. The restoration was clinically acceptable.
2	The restoration was not continuous with the existing tooth anatomy and required replacement.
	Caries in Adjacent Tooth Structure
0	Caries was not present within 3 mm of the border of the restoration.
1	Caries was present within 3 mm of the border of the restoration.
	Caries at the Cavosurface Margin
0	No caries was present on the cavosurface margin.
1	Caries was present on the cavosurface margin.
	Sensitivity
Yes	Sensitive to cold air
No	Not sensitive to cold air
	Marginal Staining
0	No staining
1	Localized staining
2	Generalized staining

Table 3: *The Distribution of Teeth According to the Location*

Cavity Lining	Dental Arch	Tooth Distribution	n	%
Lined restorations (n=50)	Upper (n=26)	Anterior	20	20.0
		Premolar	5	5.0
		Molar	1	1.0
	Lower (n=24)	Anterior	10	10.0
		Premolar	11	11.0
		Molar	3	3.0
Unlined restorations (n=50)	Upper (n=22)	Anterior	17	17.0
		Premolar	5	5.0
		Molar	—	—
	Lower (n=28)	Anterior	13	13.0
		Premolar	10	10.0
		Molar	5	5.0
Total			100	100

Photographs were taken at every step of restoration and at the recalls.

Statistical Analysis

All statistical analyses were performed using the SPSS 21.0 package. Pearson Chi-square tests were used to analyze differences between the two restorative procedures at the 5% significance level. Intra-restorative procedure comparisons of baseline and at six and 12 months posttreatment were also performed. Differences in marginal adaptation and marginal staining of restorations over time were analyzed using the two-way repeated measures test.

RESULTS

In this study there were 100 restorations in 39 patients. Twenty-eight patients received two restorations each, and 11 patients received four restorations each. Most of the carious lesions were active. The distribution of the teeth based on their location in the dental arch is shown in Table 3.

All lesions were deeper than 1 mm. The mean cavity depth was 2.18 ± 0.72 mm, mean occluso-gingival width was 3.53 ± 1.03 mm, and mean length was 4.75 ± 1.68 mm.

There were no statistically significant differences in cavity depth, length, and width and marginal adaptation as well as marginal staining rates at six, 12, and 18 months ($p>0.05$).

At baseline all restorations were adapted closely to the tooth surface, continuous with the existing tooth anatomy, and sensitivity, staining, and caries were not present. At the end of six months two lined restorations were lost. At the end of 12 months, three patients lost one of the restorations and one patient lost both restorations. One patient's tooth was extracted because of acute periodontal disease, and two patients chose crown restorations. At the end of 18 months, one patient had lost one of the restorations and one patient did not respond for recall (Table 4).

According to the results of the two-way repeated measures test, cavity lining had no effect on marginal adaptation ($p=0.566$), but changes in marginal adaptation, which was decreased over time, were significant ($p=0.0001$). According to the results of the Chi-square test, there was no significant relationship between cavity lining and marginal adaptation at six, 12, and 18 months ($p=0.187$, $p=0.557$, and $p=0.675$, respectively).

In terms of anatomic forms, all remaining restorations were continuous with the existing tooth anatomy.

No caries in the adjacent tooth structure or at the cavosurface margin were observed in either restoration group at six, 12, and 18 months, and sensitivities disappeared after the restorative rehabilitation.

At the end of six months, four teeth showed marginal staining; at the end of 12 months, 12 teeth showed staining; and at the end of 18 months 28 teeth showed marginal staining (Table 5). Two-way repeated measures test showed that there was no significant relationship between cavity lining and marginal staining ($p=0.301$). Marginal staining of the restorations was mostly localized in nature, and according to the results of the two-way repeated measures test the overall number of discolored restorations (localized and generalized) increased with time ($p=0.0001$).

Approximately 43.6% of the sample were smokers, and according to the two-way repeated measures test there was a statistically significant association between marginal staining and smoking ($p=0.038$).

Frequency of toothbrushing increased after the restorative treatment but reversed within 12 months, a finding that was insignificant according to the two-way repeated measures test ($p=0.068$). According to the Chi-square test, there was no significant relationship between marginal staining and frequency of toothbrushing at six, 12, and 18 months ($p=0.286$, $p=0.098$, and $p=0.408$, respectively).

DISCUSSION

Most root surface carious lesions do not require restorative rehabilitation. Accessible superficial le-

Table 4: *Marginal Adaptation Scores at Baseline and at Six, 12, and 18 Months*

Recall	Marginal Adaptation Scores	Cavity Lining				Total
		Unlined		Lined		
		n	%	n	%	n
Baseline	0	50	100	50	100	100
	1	—	—	—	—	
	2	—	—	—	—	
	4	—	—	—	—	
	Not applicable[a]	—	—	—	—	—
6 mo	0	46	92	42	84	88
	1	4	8	6	12	10
	2	—	—	—	—	—
	4	—	—	2	4	2
	Not applicable	—	—	—	—	—
12 mo[b]	0	34	68	30	60	64
	1	9	18	13	26	22
	2	—	—	—	—	
	4	2	4	3	6	5
	Not applicable	5	10	4	8	9
18 mo[c]	0	23	46	22	44	45
	1	15	30	17	34	32
	2	1	2	1	2	2
	4	1	2	—	—	1
	Not applicable	10	20	10	20	20
Total		50	100	50	100	100

[a] *Lost restorations, extracted teeth, or no attendance were not evaluated.*
[b] *At the end of one year, one patient did not return for recall. Three patients lost one of the restorations; another patient lost both of the restorations, whereas another patient's tooth has been extracted and two patients chose crown restoration.*
[c] *At the end of 18 months, one patient had lost one of the restorations and one patient did not return for recall.*

Table 5: *Marginal Staining at Baseline and at Six, 12, and 18 Months*

Recall	Staining	Cavity Lining			
		Unlined		Lined	
		n	%	n	%
Baseline	No staining	50	100	50	100
	Localized staining	—	—	—	—
	Generalized staining	—	—	—	—
	Not applicable	—	—	—	—
6 mo	No staining	49	98	45	90
	Localized staining	1	2	3	6
	Generalized staining	—	—	—	—
	Not applicable	—	—	—	—
12 mo	No staining	40	80	33	66
	Localized staining	3	6	9	18
	Generaliszd staining	—	—	1	2
	Not applicable	7	14	7	14
18 mo	No staining	27	54	24	48
	Localized staining	12	24	14	28
	Generalized staining	—	—	2	4
	Not applicable	11	22	10	20

sions can be made caries-free easily using hand instruments and finishing and polishing burs. Hard and leathery areas can be treated with chlorhexidine, topical fluoride application, fluoride dentifrices, and saliva.[12] Turssi and others[13] showed that saliva substitutes may induce partial remineralization in preformed caries-like lesions in the root dentin. If root surface caries are deeper than 1 mm, restorative treatment with different materials, such as amalgam, composite resin, or glass ionomer cement, is required.[14,15]

Glass ionomers (GICs) are used as a liner/base and restorative material because of their chemical bonding to the tooth substrate, long-term fluoride ion release, low coefficient of thermal expansion, acceptable esthetic quality, and biocompatibility.[16] GIC adheres strongly to dentin as the polyacrylate ions attach irreversibly to the surface of hydroxyapatite by displacing existing phosphate ions. GIC also provides micromechanical attachment to the composite.[17-19]

Banomyong and others[20] used total or self-etching adhesives and reported that the qualities of the posterior resin restorations were not significantly affected by the placement of GIC lining, regardless of the adhesive used, after one year. This corresponds with the results of the present study, in which no statistically significant differences in marginal adaptation rates were found between the lined and unlined restorations.

However, to the best of our knowledge, there are no recent clinical studies that involved restoration of root surface caries with composite resin. In 1990, Levy and Jensen[21] compared restoration of root surface caries using GIC or microfilled composite resin and reported a 73% success rate at the end of 24 months with the latter. In the present study, a success rate of approximately 90% was achieved. This higher success rate could be explained by the use of adhesives, as the previous study relied only on mechanical retention and a six months' shorter time period than was used in the present study.

As there is a lack of studies investigating restoration of root surface caries, we compared our results with the marginal adaptation scores of restorations performed on noncarious cervical lesions (NCCLs). Several studies investigated the treatment of NCCLs with bevel using different types of self-etch adhe-

sives and reported a greater than 80% success rate for marginal adaptation of restorations at the end of 12 to 24 months.[22,23] Loguercio and others[24] used one-step and two-step All Bond SE self-etch adhesives and reported an 84.8% success rate with the former at the end of 24 months. The findings of the latter study were in accordance with those of the present study, which used the same adhesive system.

It has been suggested[25] that the retention of an adhesive restoration depends on the marginal adaptation capacity as well as the viscoelastic properties of the restorative system. Several factors can bring about dimensional changes to these restorative materials, including thermal changes and water absorption.[26] In addition to using adhesive materials for marginal adaptation, retention can be better achieved by preparing the cavity such that the adhesion surface increases.[27] However, the results of the present study showed no statistically significant differences in cavity depth, length, and width and marginal adaptation rates at six, 12, and 18 months. These results do not support that increasing the size of the preparation is beneficial.

Despite the initial color match being favorable, the restoration margins may show staining over time. Kubo and others[26] compared two self-etch adhesive systems on NCCLs. They reported that at the end of two years, 20% of the restorations had slight marginal staining. Loguercio and others[24] reported that marginal staining was observed in a few restorations at 24 months. Perdigão and others[28] indicated that the number of satisfactory color ratings significantly decreased after one year with different one-step self-etch adhesive systems. In agreement with these studies, our results showed that marginal staining increased over time (5.5% at six months, 24.4% at 12 months, and 28% at 18 months).

Peumans and others[22] conducted a study on the treatment of NCCLs using composite resin and reported superficial localized margin discoloration, which was observed significantly more often in smokers, in correlation with the results of this study. In addition, regarding the effect of clinical covariables (size of lesion and toothbrushing), no correlation was found, as was the case in this study.

The frequency of root caries among young age groups was explored in this study and may partially reflect the poor oral health of Turkish people, as previously reported by Gökalp and Dogan[29] in the 2004 National Oral Health Survey. The prevalence rate of root caries in the 35-44-year-old age group was 20.1%. Most of the patients claimed that they brushed their teeth twice a day, which is sufficient for daily oral hygiene. However, these patients still presented with root surface caries. It has been suggested that though the frequency of brushing may have been enough, its duration was short, and the patient's technical knowledge was inadequate or wrong. This may be responsible for the higher incidence of root caries in younger individuals. At the beginning of this study, patients were informed about toothbrushing techniques and their importance. They were asked to brush their teeth at least twice per day. Frequency of toothbrushing was seen to increase after restorative procedures but declined after 12 months.

De Moor and others[30] reported a significantly higher incidence of recurrent caries in glass ionomer and composite resin restorations of root caries in xerostomic irradiated head and neck cancer patients after 24 months. In contrast, Hu and others[31] reported no active recurrent caries with glass ionomer restorations in their radiation-induced root surface caries study. Differences may originate from general systemic disorders of the patients. In this study, no caries were seen within the borders of the restoration. The dentifrice recommended in this study may have increased fluoride levels and thereby prevented secondary caries.[32,33]

Tooth sensitivity before restorative rehabilitation may be reduced with the help of self-etch adhesive systems. Perdigão and others[28] reported that postoperative sensitivity to air improved significantly with different self-etch adhesive systems. In the present study we found a reduction in tooth sensitivity.

The advantages of this clinical study include a paired-tooth study design, randomization, relatively high restoration number, adequate follow-up (will be continued over the duration of four successive years), and appropriate statistical analysis. Moreover, a complete description of the study methodology and results has been provided to allow comparison with other root surface caries clinical trials with similar study designs. The null hypothesis was accepted, as the lining of the restoration had no effect on the marginal adaptation, marginal staining, secondary caries, and postoperative sensitivity.

CONCLUSIONS

Within the limitations of this study, the application of cavity lining material did not affect clinical

performance, particularly marginal adaptation rate. All Bond SE exhibited good performance; both restorative techniques were considered clinically appropriate at 18 months.

Acknowledgment

This study is supported by "Hacettepe University Scientific Research Projects Coordination Unit" (H.Ü.B.A.B) with the grant number "012D06201002."

Regulatory Statement

This study was conducted in accordance with all the provisions of the local human subjects oversight committee guidelines and policies of Hacettepe University. The approval code for this study is 11/54-8.

Conflict of Interest

The Authors of this manuscript certify that they have no proprietary, financial or other personal interest of any nature or kind in any product, service and/or company that is presented in this article.

(Accepted 12 October 2015)

REFERENCES

1. Murray PE, About I, Franquin JC, Remusat M, & Smith AJ (2001) Restorative pulpal and repair responses *Journal of the American Dental Assocication* **132(4)** 482-491.
2. Hilton TJ (2009) Keys to clinical success with pulp capping: A review of the literature *Operative Dentistry* **34(5)** 615-625.
3. Costa CA, Giro EM, do Nascimento AB, Teixeira HM, & Hebling J (2003) Short-term evaluation of the pulpo-dentin complex response to a resin-modified glass-ionomer cement and a bonding agent applied in deep cavities *Dental Materials* **19(8)** 739-746.
4. Duque C, Negrini Tde C, Sacono NT, Spolidorio DM, de Souza Costa CA, & Hebling J (2009) Clinical and microbiological performance of resin-modified glass-ionomer liners after incomplete dentine caries removal *Clinical Oral Investigations* **13(4)** 465-471.
5. Strober B, Veitz-Keenan A, Barna JA, Matthews AG, Vena D, Craig RG, Curro FA, Thompson VP (2013) Effectiveness of a resin-modified glass ionomer liner in reducing hypersensitivity in posterior restorations: A study from the practitioners engaged in applied research and learning network *Journal of the American Dental Association* **144(8)** 886-897.
6. Ruiz JL, & Mitra S (2006) Using cavity liners with direct posterior composite restorations *Compendium of Continuing Education in Dentistry* **27(6)** 347-351, quiz 52.
7. Sampaio PC, de Almeida Junior AA, Francisconi LF, Casas-Apayco LC, Pereira JC, Wang L, Atta MT (2011) Effect of conventional and resin-modified glass-ionomer liner on dentin adhesive interface of Class I cavity walls after thermocycling *Operative Dentistry* **36(4)** 403-412.
8. Hebling J, Giro EM, & Costa CA (1999) Human pulp response after an adhesive system application in deep cavities *Journal of Dentistry* **27(8)** 557-564.
9. Nayyar S, Tewari S, & Arora B (2007) Comparison of human pulp response to total-etch and self-etch bonding agents *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, Endodontics* **104(2)** e45-e52.
10. Haveman CW, Summitt JB, Burgess JO, & Carlson K (2003) Three restorative materials and topical fluoride gel used in xerostomic patients: A clinical comparison *Journal of the American Dental Association* **134(2)** 177-184.
11. Moncada G, Silva F, Angel P, Oliveira OB Jr, Fresno MC, Cisternas P, Fernandez E, Estay J, Martin J (2014) Evaluation of dental restorations: A comparative study between clinical and digital photographic assessments *Operative Dentistry* **39(2)** E45-E56.
12. Peters MC. Strategies for noninvasive demineralized tissue repair (2010) *Dental Clinics of North America* **54(3)** 507-525.
13. Turssi CP, Lima RQ, Faraoni-Romano JJ, & Serra MC (2006) Rehardening of caries-like lesions in root surfaces by saliva substitutes *Gerodontology* **23(4)** 226-230.
14. Burgess JO, & Gallo JR (2002) Treating root-surface caries *Dental Clinics of North America* **46(2)** 385-404, vii-viii.
15. Saunders RH Jr, & Meyerowitz C (2005) Dental caries in older adults *Dental Clinics of North America* **49(2)** 293-308.
16. Costa CA, Ribeiro AP, Giro EM, Randall RC, & Hebling J (2011) Pulp response after application of two resin modified glass ionomer cements (RMGICs) in deep cavities of prepared human teeth *Dental Materials* **27(7)** e158-e170.
17. Yip HK, Tay FR, Ngo HC, Smales RJ, & Pashley DH (2001) Bonding of contemporary glass ionomer cements to dentin *Dental Materials* **17(5)** 456-470.
18. Wilson AD, Prosser HJ, & Powis DM (1983) Mechanism of adhesion of polyelectrolyte cements to hydroxyapatite *Journal of Dental Research* **62(5)** 590-592.
19. Chadwick RG, & Woolford MJ (1993) A comparison of the shear bond strengths to a resin composite of two conventional and two resin-modified glass polyalkenoate (ionomer) cements *Journal of Dentistry* **21(2)** 111-116.
20. Banomyong D, Harnirattisai C, & Burrow MF (2011) Posterior resin composite restorations with or without resin-modified, glass-ionomer cement lining: A 1-year randomized, clinical trial *Journal of Investigative and Clinical Dentistry* **2(1)** 63-69.
21. Levy SM, & Jensen ME (1990) A clinical evaluation of the restoration of root surface caries *Special Care in Dentistry* **10(5)** 156-160.
22. Peumans M, Munck J, Van Landuyt K, Lambrechts P, & Van Meerbeek B (2005) Three-year clinical effectiveness of a two-step self-etch adhesive in cervical lesions *European Journal of Oral Science* **113(6)** 512-518.
23. Burgess JO, Sadid-Zadeh R, Cakir D, & Ramp LC (2013) Clinical evaluation of self-etch and total-etch adhesive

systems in noncarious cervical lesions: A two-year report *Operative Dentistry* **38(5)** 477-487.

24. Loguercio AD, Manica D, Ferneda F, Zander-Grande C, Amaral R, Stanislawczuk R, de Carvalho RM, Manso A, Reis A (2010) A randomized clinical evaluation of a one- and two-step self-etch adhesive over 24 months *Operative Dentistry* **35(3)** 265-272.
25. Kurokawa H, Miyazaki M, Takamizawa T, Rikuta A, Tsubota K, & Uekusa S (2007) One-year clinical evaluation of five single-step self-etch adhesive systems in non-carious cervical lesions *Dental Materials Journal* **26(1)** 14-20.
26. Kubo S, Yokota H, Yokota H, & Hayashi Y (2009) Two-year clinical evaluation of one-step self-etch systems in non-carious cervical lesions *Journal of Dentistry* **37(2)** 149-155.
27. Mazhari F, Mehrabkhani M, Sadeghi S, & Malekabadi KS (2009) Effect of bevelling on marginal microleakage of buccal-surface fissure sealants in permanent teeth *European Archives of Paediatric Dentistry* **10(4)** 241-243.
28. Perdigao J, Dutra-Correa M, Castilhos N, Carmo AR, Anauate-Netto C, Cordeiro HJ, Amore R, Lewgoy HR (2007) One-year clinical performance of self-etch adhesives in posterior restorations *American Journal of Dentistry* **20(2)** 125-133.
29. Gökalp S, & Dogan BG (2012) Root caries in 35-44 and 65-74 year-olds in Turkey *Community Dental Health* **29(3)** 233-238.
30. De Moor RJ, Stassen IG, van't Veldt Y, Torbeyns D, & Hommez GM (2011) Two-year clinical performance of glass ionomer and resin composite restorations in xerostomic head- and neck-irradiated cancer patients *Clinical Oral Investigations* **15(1)** 31-38.
31. Hu JY, Chen XC, Li YQ, Smales RJ, & Yip KH (2005) Radiation-induced root surface caries restored with glass-ionomer cement placed in conventional and ART cavity preparations: Results at two years. *Australian Dental Journal* **50(3)** 186-190.
32. Arbabzadeh-Zavareh F, Gibbs T, Meyers IA, Bouzari M, Mortazavi S, & Walsh LJ (2012) Recharge pattern of contemporary glass ionomer restoratives *Dental Research Journal (Isfahan)* **9(2)** 139-145.
33. Hara AT, Turssi CP, Ando M, Gonzalez-Cabezas C, Zero DT, Rodrigues AL Jr, Serra MC, Cury JA (2006) Influence of fluoride-releasing restorative material on root dentine secondary caries in situ *Caries Research* **40(5)** 435-439.