Original Article

Comparative Evaluation of Marginal Integrity of Three Esthetic Restorative Materials – An *In-vitro* Study

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Abstract

Context: Microleakage is the major cause for the failure of dental restorations, especially in Class V cavities, as margins of such restorations are generally located in dentin or cementum. Microleakage evaluation is necessary as a means of evaluation of the marginal integrity of restorative materials. This would assist in developing techniques and materials that would reduce damage caused by the failure of the restorative marginal seal. **Aim:** The aim of this study is to analyze and compare the marginal integrity among three esthetic restorative materials, namely GC Fuji II LC, GC G-Aenial anterior composite resin, and GC Equia forte fil. **Setting and Design:** Sixty orthodontically extracted caries-free premolar teeth with Class V restorations were divided into three groups. Microleakage was measured using an ordinal scale of 0–4, as given by Khera and Chan, in increasing order of dye penetration, which was observed under a microscope. **Materials and Methods:** Study was conducted in sound human extracted premolars in which Standardized Class V cavities were prepared. Teeth were randomly and equally assigned to three groups (GC Fuji II LC, GC G-Aenial anterior composite resin, and GC Equia forte fil). Teeth were sectioned longitudinally into two halves using diamond discs and the sectioned halves of the teeth were evaluated for dye penetration under stereomicroscope. **Statistical Analysis Used:** Intergroup comparison of mean dye penetration scores were compared using the Kruskal–Wallis test along with *post hoc* pairwise comparison by Mann Whitney U test. The level of statistical significance was set at 0.05. **Results and Conclusion:** All the three groups (GC Fuji II LC, GC G-Aenial anterior composite resin, and GC Equia forte fil) tested showed microleakage at the tooth restoration interface. It was evident that microleakage was found to be highest with the Fuji II LC, both at occlusal and cervical levels. GC Equia forte exhibited the best performance in limiting microleakage around the restoration margins.

Keywords: *GC Equia Forte Fil, GC Fuji II LC, GC G-Aenial composite resin, glass ionomer cement, microleakage*

Introduction

Microleakage is defined as the chemically undetectable passage of bacteria, fluids, molecules, or ions between the cavity walls and restorative materials. Clinically, microleakage is the major cause for the failure of dental restorations, especially in Class V cavities, as margins of such restorations are generally located in dentin/cementum.[1]

Dental restorations attempt to restore the shape, function, and esthetics caused by the loss of dental tissue. To choose the most adequate restorative material, the clinician must take into account factors such as biological, optical, mechanical, and manipulative properties. Adhesiveness and sealing ability of the material have to be considered while selecting the restorative material.[2]

Over the years, demand for esthetic dentistry has shown considerable progress, leading to the development of a number of improved restorative materials. Currently, the main concerns regarding the performance of these materials are their durability and marginal seal integrity. Despite technical innovations and restorative material improvements, microleakage is still a concern in clinical practice.[3] Earlier amalgam and gold restorative materials were used to restore Class V cavities but became obsolete mainly because of their esthetic shortcomings. Nowadays, restorative materials such as glass ionomers, hybrid ionomers, compomers, and composite resins, are recommended to restore Class V cavities.[1] The marginal leakage, mainly

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in restorations with cervical margin in dentin, is considered responsible for hypersensitivity, secondary caries, marginal discoloration, and pulpal pathologies. Marginal sealing is known to influence the longevity of dental restorations.[2]

Microleakage can result in long-term consequences as marginal discoloration, secondary caries, postoperative sensitivity pulpal pathology.[3] Technological improvements have taken place in response to the growing demand of the patients for esthetics and the consequent demand of clinicians for materials with similar optical characteristics to those of the natural teeth.[4] Microleakage evaluation is required to develop techniques and materials that reduce or delay damage caused by the failure of restorative marginal sealing. Laboratory tests estimate the material's sealing ability, and clinical significance presumes invasion of bacteria through substrates/restorative material interface. Maximum penetration of a tracer substance seems to be the best criteria on microleakage degree determination. Digital photographs (large zoom and high resolution) of sectioned specimens after immersion in the chemical tracer, enables proper microleakage measurement with the aid of a computer program.[3] This would assist in developing techniques and materials that would reduce or delay damage caused by the failure of the restorative marginal seal.

Class V cavities are characteristic for presenting little or no enamel at the cervical margins, which has been considered a great challenge for the achievement of an adequate adhesion.[2] Several restorative options are available and have been studied for cervical restorations but have generally given contradictory results due to different compositions, mechanical properties, differences in techniques, and lack of standardization.

Thus, the present study was planned to evaluate and compare the microleakage of three different types of esthetic restorative materials with indications for use in primary teeth, namely: GC Fuji II LC, GC G-aenial, and GC Equia forte.

Materials and Methods

The present study was done in the Department of Pediatric and Preventive Dentistry, School of Dental Sciences, Sharda University. In accordance with similar studies,[5,6] sixty intact premolars, freshly extracted for orthodontic reasons, were used for this study. They were collected and stored in distilled water. The premolar teeth were randomly and equally assigned to three groups each, namely:

- Group A: GC Fuji II LC
- Group B: GC G-Aenial anterior composite resin
- Group C: GC Equia Forte Fil.

Standardized Class V cavities were prepared on all 60 premolar teeth. Preparations were centered 1mm above the cementoenamel junction and were approximately 2 mm in-depth, 3 mm in occluso gingival height, and 5 mm in mesio-distal width. Care was taken to maintain 90°cavosurface angles at all cavity margins with no deliberate mechanical retention**.** In all the three groups, restorations of the prepared cavities were carried out according to the manufacturer's instructions**.** Restored teeth were then stored in distilled water for a week. After a week, apices of teeth were sealed using sticky wax, and the specimens were coated with two layers of nail varnish, leaving a 1 mm window around the restoration margins [Figure 1].

The teeth were then immersed in an aqueous solution of 2% methylene blue for 48 h at room temperature, then removed from the dye, rinsed in tap water for 30 seconds and dried. Then, the teeth were sectioned longitudinally into two halves using diamond discs in a buccolingual direction under constant water cooling. The sectioned halves of the teeth were evaluated for dye penetration under a stereomicroscope (20) and graded according to criteria described by Khera and Chan[7,8] in 1978. Microleakage Scoring System [Figure 2].

- 0 – No leakage
- 1 – Less than or up to one half of the depth of the cavity preparation
- 2 – More than one half of the cavity preparation involved, but not up to the junction of the axial wall and occlusal or cervical wall
- 3 – Up to the junction of the axial wand occlusal or cervical wall, but not including the axial wall
- 4 – Due penetration, including the axial wall.

Results

Statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS) version 21 (SPSS Version 21.0. Armonk, NY: IBM Corp.). Absolute and Relative frequencies of different microleakage scores among different groups were compared using the Chi-square test. Intergroup comparison of Mean dye penetration scores were compared using the Kruskal–Wallis test along with *post hoc* pair-wise comparison by Mann–Whitney U-test. The level of statistical significance was set at 0.05.

At the occlusal level, the distribution of different dye penetration scores among the three study groups was compared by using Chi-Square Test and it was found that

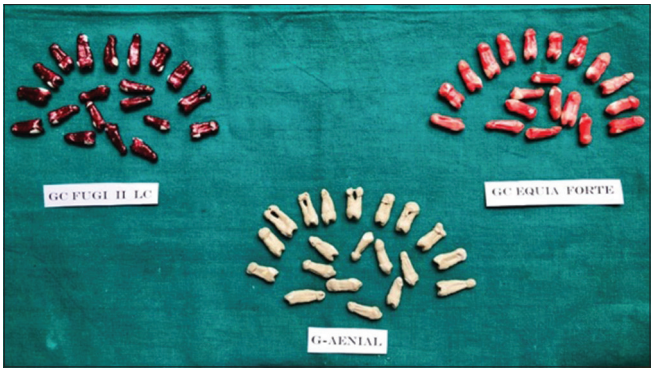

Figure 1: Nail varnish painted teeth

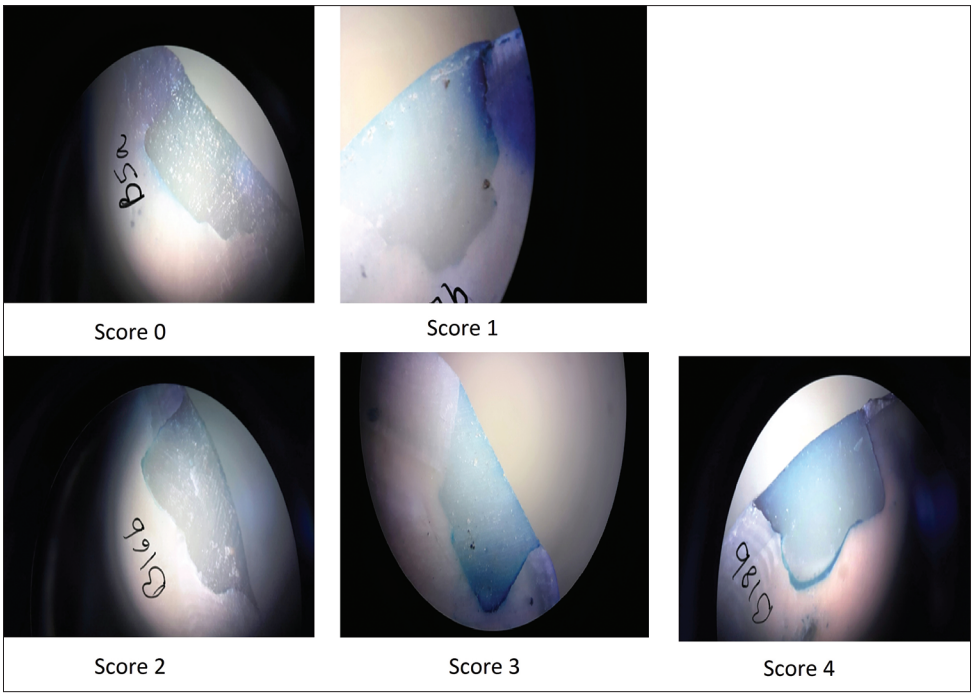

Figure 2: Microleakage Scoring System

the distribution was significantly different among the study groups. Score 0 was found to be more among Group C, score 1 was found to be more among Group B, score 2 was found to be more among Group B, score 3 was found to be more among Group A, and score 4 was found to be more among Group A [Table 1 and Figure 3].

At the cervical level, the distribution of different dye penetration scores among the three study groups was significantly different. Score 0 was found to be more among Group C, score 1 was found to be more among Group B and Group C, score 2 was found to be more among Group B, score 3 was found to be more among Group B, and score 4 was found to be more among Group A [Table 2 and Figure 4].

At the occlusal level, intergroup comparison of mean dye penetration scores was performed using Kruskal–Wallis test, and a statistically significant difference was found between them. Mean dye penetration scores among Group A and Group B samples were found to be significantly more than that among Group C samples. No statistically significant difference could be found between Group A and Group B samples with respect to the mean dye penetration score [Table 3 and Figure 5].

At the cervical level, intergroup comparison of mean dye penetration scores was performed by using the Kruskal Wallis test, and a statistically significant difference was found between them. Mean dye penetration scores among Group A was found to be significantly more than that among Group B, which was further significantly more than that among Group C samples [Table 4 and Figure 5].

Table 1: Distribution of dye penetration scores among three groups at occlusal level

GROUP		Dye penetration Score					Total
		0	1	2	3	4	
Group A	*n*	14	10	1	3	12	40
	%	35.0%	25.0%	2.5%	7.5%	30.0%	100
Group B	*n*	10	20	6	2	2	40
	%	25.0%	50.0%	15.0%	5.0%	5.0%	100
Group C	*n*	29	10	0	0	1	40
	%	72.5%	25.0%	0.0%	0.0%	2.5%	100
Total	*n*	53	40	7	5	15	120
	%	44.2%	33.3%	5.8%	4.2%	12.5%	100
P[a]		<0.000*					

[a]Chi square test. *Statistically significant

Intergroup comparisons at the occlusal level placed Fuji II LC at the maximum dye penetration levels, showing statistically significant differences with the other two materials. However, there was no statistically significant difference between the other two materials in terms of occlusal dye penetration scores. Further, at the cervical level Fuji II LC exhibited maximum dye penetration scores, G-Aenial ranking second and Equia Forte third, a statistically significant difference being observed between each combination of comparisons.

Discussion

Esthetic restorative material has contributed to enhancing the quality of restorative dentistry. One of the major problems associated with the restorations is the microleakage around restorations leading to recurrent

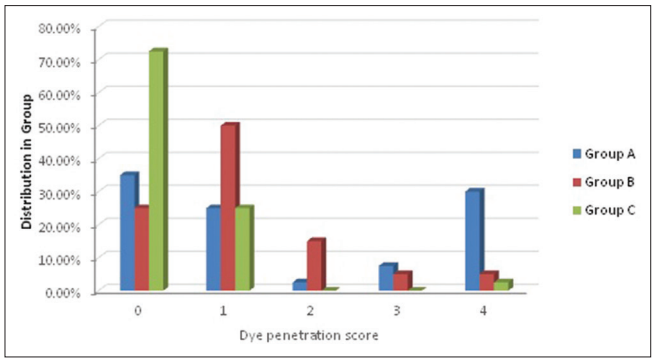

Figure 3: Distribution of dye penetration scores at occlusal level

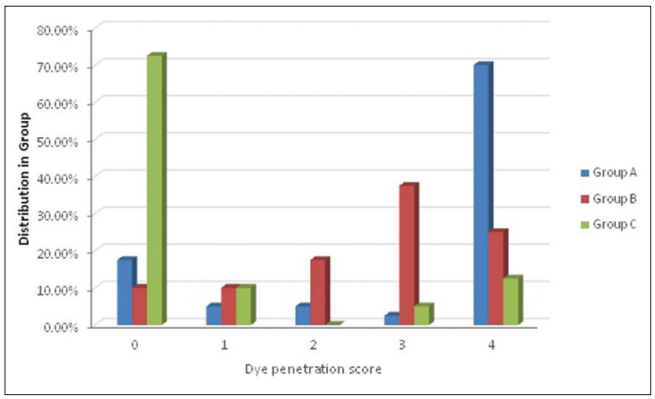

Figure 4: Distribution of dye penetration scores at cervical level

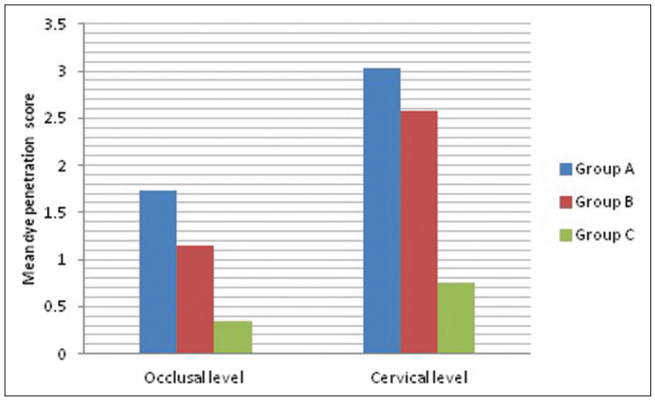

Figure 5: Intergroup comparison of mean dye penetration score at occlusal and cervical level

caries, hypersensitivity, pulpal inflammation, and accelerated deterioration of some restorative materials. Thus, this study was undertaken to compare and evaluate the marginal integrity among three esthetic restorative materials, namely GC Fuji II LC, GC G-Aenial anterior composite resin, and GC Equia Forte Fil.

The integrity and durability of the marginal seal have always been prime concerns in the performance of dental restorative materials. The search for an ideal restorative material that would create a permanent and perfect seal between restoratives margin and tooth structure reflects the constant introduction of new products in the market.

Table 2: Distribution of dye penetration scores among three study groups at cervical level

GROUP		Dye penetration Score					Total
		0	1	2	3	4	
Group A	*n*	7	2	2	1	28	40
	%	17.5%	5.0%	5.0%	2.5%	70.0%	100
Group B	*n*	4	4	7	15	10	40
	%	10.0%	10.0%	17.5%	37.5%	25.0%	100
Group C	*n*	29	4	0	2	5	40
	%	72.5%	10.0%	0.0%	5.0%	12.5%	100
Total	*n*	40	10	9	18	43	120
	%	33.3%	8.3%	7.5%	15.0%	35.8%	100
P[a]		<0.000*					

[a]Chi square test. *Statistically significant

Different methods used for microleakage assessment includes silver nitrate, air pressure, Dye study, radioactive isotopes, and scanning electron microscope (SEM). The dye penetration method was used in this study to assess the microleakage. 2% Methylene blue was used as a dye indicator in the study as it provides a simple, quantitative, economical, and comparable method of evaluating the various restorative materials.[2]

Class V cavity preparation was done as it has a high cavity configuration factor (C-factor) value to evaluate the microleakage at the tooth restoration interface. C-factor is the ratio of the bonded surface area in a cavity to the unbonded surface area.[9] Glass ionomers seem to be the material of choice in Class I and Class V cavities in primary teeth.[10] There is substantial evidence to support the use of glass ionomers for Class V restorations in young permanent teeth in high-risk patients and also as interim therapeutic restoration.[11] However, disadvantages related to glass ionomers, such as lack of strength, prolonged setting time, moisture sensitivity, dehydration, and poor esthetics are reported.

Hand mixing of GICs might allow for an increased incidence of operator errors during material preparation, as the ratio of powder to liquid may vary according to the manufacturer's recommendations.[12] With the purpose of decreasing variability, encapsulated dental cements have been introduced in the market. The GC Equia Forte is one such encapsulated product, introduced in 2015.

Diwanji *et al*. in 2014 evaluated the microleakage and found maximum microleakage around conventional GIC restorations, followed by RMGIC and least microleakage around nanoionomer restorations.[13] Mali *et al*. found a similar result with more microleakage with conventional glass ionomer as compared to resin glass ionomer and composite.[14] In contrast to these studies, our study demonstrated that encapsulated GIC, GC Equia Forte Fil, exhibited the least microleakage levels among the three materials tested. Factors that may have contributed to make GC Equia Forte Fil exhibit least microleakage in this study were that it does not require any layering, is nonsticky and

Table 3: Intergroup comparison of Mean dye penetration scores at occlusal level

Group	*n*	Mean	Std. Deviation	*P*[b]	*Post hoc* pairwise comparison[c]
Group A	40	1.73	1.710	<0.0001*	Group A* Group B-0.409
Group B	40	1.15	1.027		Group A * Group C <0.0001*
Group C	40	0.35	0.736		Group B*Group C <0.0001*

[b]Kruskal Wallis test, [c]Mann Whitney U test, *Statistically significant.

Table 4: Intergroup comparison of Mean dye penetration scores at cervical level

Group	*n*	Mean	Std. Deviation	*P*[b]	*Post hoc* pairwise comparison[c]
Group A	40	3.03	1.609	<0.0001*	Group A*Group B-0.01*
Group B	40	2.58	1.259		Group A * Group C <0.0001*
Group C	40	0.75	1.428		Group B*Group C <0.0001*

[b]Kruskal Wallis test, [c]Mann Whitney U test, *Statistically significant.

packable, and adapts nicely to the cavity walls. Further, it chemically attaches to the tooth structure, eliminating the need for bonding procedures and has minimal or no shrinkage stress.[15] Glass ionomers may produce adequate marginal sealing since chemical interactions take place with polyalkenoic acids and hydroxyapatite. The strong chelation reaction with calcium on the tooth surface might have made this material comparable to nano-filled glass ionomers.[16]

The study illustrated that GC Equia Forte, a modified encapsulated GIC, exhibited least microleakage along its restoration borders. The difference was statistically significant ($P < 0.05$). In terms of microleakage, the resin-modified GIC (Fuji II LC) came second and third was the composite resin (G-Aenial). However, the difference between the two materials was not statistically significant ($P > 0.05$).

GC EQUIA Forte is an innovative restorative system based on a new glass hybrid technology. It combines a filling component with a protective composite coating while additionally benefiting from a newly developed hybrid filler technology. The new system makes use of the advantages of combined different size filler technologies, in a way similar to hybrid composites.[15] One of the differentials of this hybrid restorative system is the surface protection of the restorations, which is accomplished by applying a light-cured resin sealant that seems to improve the final smoothness of the restoration and reduce surface wear.[17]

GC G-Aenial anterior composite material exhibited more microleakage than Equia Forte in this study. Polymerization shrinkage may be the reason for this finding. Contemporary composite materials shrink during polymerization, resulting in a volumetric reduction ranging from 1.5 to 5% depending on the molecular structure of the monomer, the amount of filler, and the rate of cure.[18]

GC G-Aenial is a hybrid composite with two different kinds of pre-polymerized fillers (Strontium and Lanthanoid fluoride), offering clinical useful radiopacity while keeping perfect aesthetics. The pre-polymerized fillers also contribute to the low level of shrinkage found with G-ænial. G-Aenial is bis-GMA free. However, volumetric shrinkage is reported to be 2.4% with this material,[19] a fact that could explain its relatively inferior sealing ability in this study compared to encapsulated GIC. The esthetic appeal of GC G-Aenial is its main advantage.

Resin-modified GIC (GC Fuji II LC) exhibited the most microleakage in this study. Factors that may have been responsible for this finding were that hygroscopic expansion of the material may have weakened the bond of the material with the tooth, leading to leakage.[14] Further, the resin content may have led to increasing polymerization shrinkage. This finding is in agreement with some studies that mention GIC undergo minimal setting shrinkage and approximately one-half that of resins.[20] Besides the advantages of glass ionomers, its ease of placement, early resistance to moisture contamination, and setting in the command. RMGIC resulted in improved esthetics in comparison to conventional glass ionomers.

The observations from this study were that all three materials investigated exhibited more microleakage on the gingival margins than on the occlusal margins because the flexural stresses at cervical margins are higher than that at the occlusal margins, which is in accordance with previous studies by Nayak *et al*.[21] and Kumar Gupta *et al*.[22]

Groups A (GC Fuji II LC) and B (GC G-Aenial) showed high levels of dye penetration both at the occlusal and gingival margins compared to Group C (GC Equia Forte fil). The difference was statistically significant overall microleakage scores as well as intergroup microleakage scores ($P < 0.05$). High flexibility, hybrid fillers, uniform consistency, and low volumetric shrinkage of GC Equia Forte fil may be the possible reason for less microleakage compared to the other two groups. The difference observed in the microleakage between the enamel (occlusal) and dentin (gingival) margins may be due to a difference in the quality of the bond between the materials and enamel and dentin structures. This is explained by the fact that cavity preparations with enamel margins result in stronger bonds since the inorganic

structure is higher in enamel than dentin. This finding is in accordance with reports that enamel (occlusal) margins of permanent teeth restored with GICs show less microleakage than dentin (gingival) margins.[23]

The main disadvantages with the form of microleakage assessment used in this study are that it is usually associated with the assigning of a numerical scoring system of increasing degrees of leakage and that this assessment, although often carried out by more than one examiner, is somewhat subjective. Further, the assessment of the restoration as a whole is difficult when viewing only individual small sections of the tooth.

With the introduction of newer materials claiming superior properties, it becomes imperative to evaluate them, especially in relation to their marginal integrity, to be able to use them predictably. Hence, this study was undertaken to evaluate the marginal integrity of new restorative materials available in the market.

Conclusion

The longevity of the restoration is largely determined by the marginal sealing of the cavity. Hence minimizing microleakage at the tooth/restoration interface is important in predicting its clinical success. In the present study, microleakage was present with all three restorative materials. GC Equia Forte Fil exhibited the best performance in limiting microleakage around the restoration margins. Elaborate *in vitro* and clinical studies are indicated to authenticate and establish the reliability of conclusions drawn from the study. The continual search for an ideal marginal sealing restorative material will continue.

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Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Bollu IP, Hari A, Thumu J, Velagula LD, Bolla N, Varri S, *et al*. Comparative Evaluation of Microleakage Between Nano-Ionomer, Giomer and Resin Modified Glass Ionomer Cement in Class V Cavities-CLSM Study. J Clin Diagn Res 2016;10:ZC66-70.
2. Lund RG, Carvalho RV, Rodrigues-Junior SA, Dermarco FF. Sealing ability of different adhesive restorative materials. Rev Odontol UNESP 2009;38:204-10.
3. Lise DP, Lopes GC, Maia HP, Baratieri LN. Microleakage of composite inlays luted with self-adhesive cements. Dent 2014;4:221.
4. Nahsan FP, Mondelli RF, Franco EB, Naufel FS, Ueda JK, Schmitt VL, Baseggio W. Clinical strategies for esthetic excellence in anterior tooth restorations: Understanding color and composite resin selection. J App O Sci 2012;20:151-6.
5. Hasani Z, Khodadadi E, Ezoji F, Khafri S. Effect of mechanical load cycling on microleakage of restorative glass ionomers compared to flowable composite resin in class V cavities. Front Dent 2019;16:136-43.
6. Ranjbar Omidi B, Madani L, Mirnejad Joybari A, Rashvand E, Oveisi S. Effect of mechanical load cycling on the microleakage of three different glass ionomer restorations in class V cavities. J Dent Med 2015;28:95-102.
7. Khera SC, Chan KC. Microleakage and enamel finish. J Prosthet Dent 1978;39:414-9.
8. Nandana KL, Sai Sankar AJ, Manoj Kumar MG, Naveen K, Pranitha K, Manjula BS. Comparative evaluation of microleakage using three variables of glass-ionomer cement in primary and permanent teeth: An *in vitro* study. J Interdiscip Dent 2016;6:110-5.
9. Ilie N, Jelen E, Clementino-Luedemann T, Hickel R. Low-shrinkage composite for dental application. Dent Mater J 2007;26:149-55.
10. Tran LA, Messer LB. Clinicians' choices of restorative materials for children. Aust Dent J 2003;48:221-32.
11. Burke FJ, Wilson NH, Cheung SW, Mjör IA. Influence of patient factors on age of restorations at failure and reasons for their placement and replacement. J Dent 2001;29:317-24.
12. Billington RW, Williams JA, Pearson GJ. Variation in powder/liquid ratio of a restorative glass-ionomer cement used in dental practice. Br Dent J 1990;169:164-7.
13. Diwanji A, Dhar V, Arora R, Madhusudan A, Rathore AS. Comparative evaluation of microleakage of three restorative glass ionomer cements: An *in vitro* study. J Nat Sci Biol Med 2014;5:373-7.
14. Mali P, Deshpande S, Singh A. Microleakage of restorative materials: An *in vitro* study. J Indian Soc Pedod Prev Dent 2006;24:15-8.
15. Available from: https://cdn.gceurope.com/v1/PID/equiaforte/leaflet/LFL_A_Comprehensive_Guide_to_EQUIA_Forte_en.pdf [Last accessed on 2017 Jan 23].
16. Eronat N, Yilmaz E, Kara N, Ak AT. Comparative evaluation of microleakage of nano-filled resin-modified glass ionomer: An *in vitro* study. Eur J Dent 2014;8:450-5.
17. Freitas MC, Fagundes TC, Modena KC, Cardia GS, Navarro MF. Randomized clinical trial of encapsulated and hand-mixed glass-ionomer ART restorations: One-year follow-up. J Appl Oral Sci 2018;26:e20170129.
18. Bouillaguet S, Gamba J, Forchelet J, Krejci I, Wataha JC. Dynamics of composite polymerization mediates the development of cuspal strain. Dent Mater 2006;22:896-902.
19. Available from: https://cdn.gceurope.com/v1/PID/gaenial/manual/MAN_G-aenial_Anterior Posterior_en.pdf. [Last accessed on 2017 Jan 23].
20. 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.
21. Nayak UA, Sudha P, Vidya M. A comparative evaluation of four adhesive tooth coloured restorative materials. An *in vitro* study. Ind J Dent Res 2002;13:49-53.
22. Kumar Gupta S, Gupta J, Saraswathi V, Ballal V, Rashmi Acharya S. Comparative evaluation of microleakage in Class V cavities using various glass ionomer cements: An *in vitro* study. J Interdiscip Dent 2012;2:164-9.
23. Wadenya R, Mante FK. An *in vitro* comparison of marginal microleakage of alternative restorative treatment and conventional glass ionomer restorations in extracted permanent molars. Pediatr Dent 2007;29:303-7.