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Original Research

Evaluation of the Effect of Different Food Media on the Marginal Integrity of Class V Compomer, Conventional and Resin-Modified Glass-Ionomer Restorations: An *In Vitro* Study

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Abstract:

Background: Cervical lesions of anterior and posterior teeth are a common finding in routine dental practice. They are of much concern to the patient, if present in esthetically sensitive regions. Adhesive tooth-colored restorative materials are generally recommended for treating such lesions. The aim of the present study was to evaluate and compare the effect of various food media (lime juice, tea, coffee, and Coca-Cola) on the marginal integrity of Class V compomer (Dyract®), conventional glass-ionomer (Fuji II) and resin-modified glass-ionomer (Fuji II LC improved) restorations along their cemental and enamel margins with saline as control media.

Materials and Methods: After restoration of prepared Class V cavities in human premolars with the three different materials (n = 8), they were immersed in the test media for 7 days and then stained with methylene blue dye. Buccolingual sections were prepared and examined under stereomicroscope and scores (0-2) were given.

Results: Data were analyzed statistically using one-way analysis of variance in SPSS version 16.0. $P < 0.05$ were considered statistically significant.

Conclusions: Among the three tested materials Compomer (Dyract®) showed more marginal integrity than the other two. Micro leakage values of Fuji II and Fuji II LC improved were statistically significant in acidic media (lime juice and Coca-Cola) compared to saline. Enamel margins showed more marginal adaptation than cemental margins.

Key Words: Acidic media, cementum, conventional glass-ionomer, lime juice, titratable acidity

Introduction

Non-carious cervical lesions can be of multifactorial origin such as erosion, abrasion, and abfractions. Whereas for cervical carious lesions the etiology may be poor patient oral hygiene, high sugar diet, endocrine disorders, and other conditions that reduce salivary flow. The special characteristics of cervical lesions are the presence of cementum or dentin in the gingival margins. Hence, restorative materials that have good bonding to both enamel and cementum or dentin should be considered for restoring such lesions. Since adhesive esthetic restorative materials need minimal or no tooth preparation and have color matching with the remaining tooth structure, they are specifically indicated for the restoration of cervical lesions. Among them, glass-ionomer cements are more preferred by clinicians due to their chemical bonding ability and ease of placement. In the long run, the various etiologies, locations, and structural characteristics make cervical lesions more challenging to adhesive restorative procedures and marginal seal.[1]

Glass-ionomers are referred to as smart restorative materials as they not only release fluoride to the surrounding tooth structure, but also have a semi-permeable surface that allows calcium and phosphate ions present in saliva to pass through the material and combine with the fluoride to produce remineralization of the enamel as a fluorapatite. Furthermore, it provides a high burst of fluoride for remineralization as well as prolonged fluoride release over time.[2] Conventional glass-ionomer cements are hydrolytically unstable in its early stages. They are highly sensitive to water uptake and water loss for up to 24 h, during which they have to be isolated from the oral environment with adequate surface protection.[3] Fluoride released from glass-ionomers also has antimicrobial action against *Streptococcus mutans* in plaque.[4] Resin-modified glass-ionomers have resin component usually hydroxyethylmethacrylate grafted to the acidic liquid component resulting in a complex liquid that maintains acid reactivity and activity to be light polymerized.[5] The resin component improves setting characteristics, early strength, and renders the set matrix less intolerant to the effect of moisture. Compomers contain the major ingredients of both composites (resin component) and glass-ionomer cements (poly alkenoate acid and glass filler component) except for water.[6] The dominant setting reaction in these materials is the resinous polymerization, and no acid-base reaction can occur until later when the material absorbs water.[5]

Marginal ingress of oral fluids and bacteria can cause recurrent caries, sensitivity, marginal staining, pulpal pathology, and failure of restorations. It is defined as the clinically undetectable passage of bacteria, fluids, molecules or ions between the cavity wall and the restorative material applied to it.[7] Chemical factors

such as acids and components of the restorative materials are less significant in causing pulpal injury than bacterial leakage along the restoration margins.[8] Several factors influence the micro leakage at the tooth restoration interface such as the nature of restorative material used, polymerization shrinkage, hygroscopic expansion, thermal and mechanical stress, and dietary habits of the patient. The food consumed by an individual can change the temperature of the oral environment to a wide range. These factors may influence the properties of the restorative material as well as the adhesion between tooth and restoration. Although several studies had been conducted to determine micro-leakage of these three materials in Class V lesions, there is still controversy regarding which of these materials is more suited for restoring cervical lesions in an acidic environment, which is a major causative factor for such lesions. The present study was conducted to compare and evaluate the micro leakage along the incisal and cervical margins of Class V restoration of Dyract® (Compomer), Fuji II (Conventional glass-ionomer) and Fuji II LC improved (Resin-modified glass-ionomer) immersed in common food beverages such as tea, coffee, low PH carbonated drink (Coca-Cola), and lime juice with saline as control.

Materials and Methods

One hundred and twenty freshly extracted human premolars for orthodontic purposes which were free of caries, erosion, abfraction or abrasion were selected for this study. They were thoroughly cleaned and stored in distilled water. Class V tooth preparations were made on the buccal surface using no 330 tungsten carbide bur at high speed with air water coolant. Preparations were centered on the cementoenamel junctions and were approximately 1.5 mm deep, 4 mm height, and 3 mm width. 90° cavosurface angle was maintained at all cavity margins. The teeth were then randomly divided into three groups (Group I, Group II, and Group III) with 40 teeth in each group.

The teeth in Group I were acid etched with 37% phosphoric acid gel (Fusion etch, Fusion dental products) for 30 s, followed by application of prime and Bond® NT and light-cured for 10 s. Dyract® was placed incrementally, and each layer was light cured (Litex 680 A, Dentamerica) for 40 s. The restorations were finished with abrasive discs (Solf – Lex disks, 3M dental products), and lightly air-dried and unfilled resin was applied, and light-cured. The teeth were then stored in distilled water for 24 h.

Teeth in Group II were restored with Fuji II after conditioning with 10% polyacrylic acid for 10 s. The restored surfaces were coated with GC Fuji varnish (GC Corporation, Tokyo) and stored in distilled water at room temperature for 24 h, followed by final finishing with abrasive disks (Soft – Lex Disks, 3M Dental Products) and varnish application. Teeth in Group III were restored using Fuji II LC improved after conditioning with 10% polyacrylic acid (GC Dentin Conditioner, GC Corporation, Tokyo) for 10 s. The restoration was light-cured for 20 s from the labial aspect and both mesial and distal aspects. Surface of the restoration was coated with GC Fuji varnish. The restored teeth were stored in distilled water at room temperature for 24 h. Final finishing was done after 24 h using abrasive disks (Soft – Lex disks, 3M dental products) under water spray and varnish applied. The composition of the restorative materials tested is given in Table 1

The teeth in three groups were then thermo cycled for 200 cycles ranging from 5 ± 5°C to 55 ± 5°C each with dwell time of 30 s in thermocycling unit (LTC 100, LAM technologies, Italy). After thermocycling, the apices of the teeth were sealed with sticky wax. The teeth in the three groups (Group I, II and III) were subdivided into five subgroups (A, B, C, D and E) of eight teeth each and were immersed in tea, coffee, Coca-Cola, lime juice, and saline respectively for 7 days. The media were freshly prepared and changed in every 24 h. The test medium, tea was prepared by adding one teaspoon tea dust to 160 ml of water. Lime juice was prepared by adding 5 ml of lime extract to 160 ml distilled water. Coffee was prepared by adding one teaspoon coffee powder to 160 ml of water. 0.9% saline (RUSOMA Laboratories, Indore, Madhya Pradesh, India) and Coca-Cola (Coca-Cola Co, Kerala) were the other test media used. The pH of the immersion media

Table 1: Composition of the test materials.

Group	Materials	Powder: liquid ratio (g/g)	Type of material	Composition	Manufacturer
I	Dyract® Prime and Bond® NT	Compule Liquid	Compomer Bonding agent	UDMA resin, TCB resin, strontium-fluoro – silicate glass, strontium fluoride, photo initiators, stabilizers Di and trimethacrylates resins, functionalized amorphous silica, PENTA, photoinitiators stabilizers, cetylamine hydrofluoride, acetone	De Trey, Dentsply De Trey, Dentsply
II	Fuji II	2.7:1	Conventional glass-ionomer	Powder-fluoroalumino silicate glass Liquid-copolymer of acrylic and maleic acids polybase carboxylic acid, water	GC Corp.; Tokyo, Japan
III	Fuji II LC Improved	3:1	Resin-modified glass-ionomer	Powder-aluminosilicate glass, pigments Liquid-polyacrylic acid, distilled water, HEMA (17%) dimethacrylate monomer, camphoroquinone	GC Corp.; Tokyo, Japan

UDMA: Urethane dimethacrylate, TCB: Carboxylic acid modified dimethacrylate, HEMA: Hydroxyethylmethacrylate, PENTA: Dipentaerythritol pentacrylate phosphoric acid ester

were detected using pH meter (pH probe, Mettler Toledo International Inc.; India) and is given in Table 2.

After removing from the test media, the teeth were washed and dried. All teeth surfaces except 1 mm wide zone around the margins of each restoration were coated with a layer of fingernail varnish. The coated teeth were immersed for 4 hrs in 10% solution of methylene blue dye. After removal from the dye, the coatings were removed from the teeth and lightly pumiced to remove the superficial dye. Buccolingual sections through the restoration were prepared by placing a grove on the labial and palatal surfaces with diamond discs and the teeth sectioned using chisel and mallet The sections were then examined and photographed using stereomicroscope (Olympus, Japan) at ×20 magnification. Scorings were given for micro leakage ranging from 0 to 2 as given in table 3.

Results

The data obtained were analyzed statistically using one-way analysis of variance using SPSS version 16.0 and is summarized in Table 4. These data are presented graphically in Graphs 1-3. Stereomicroscopic images at ×20 magnification for various micro leakages are given in Figures 1-3. $P < 0.05$ were considered statistically significant and values <0.01 were statistically highly significant.

Table 2: pH of immersion media.

Group	Immersion media	pH
A	Tea	5.04
B	Coffee	5.32
C	Coca-Cola	2.44
D	Lime	3.79
E	Saline	7.00

Table 3: Scoring system.

Score	Description
0	No leakage cervically/incisally
0.5	Leakage half the length of incisal/cervical wall
1	Leakage extending along the full length of incisal/cervical wall
1.5	Leakage along the full length of cervical/incisal wall and extending towards the incisal/cervical wall respectively occupying half the length of this wall
2	Leakage along the full length of incisal and cervical wall and extending through the dentinal tubules into the pulp chamber

Discussion

Adhesion to the walls of the tooth preparation is an important property for any restorative material to prevent micro leakage. This bond should not be affected by environmental changes and functional stresses in the oral environment, in order to prevent the development of secondary caries and further deterioration of tooth structure. So while considering a material for restoration, marginal integrity is an important concern. With the desire for aesthetic dentistry and concern over the

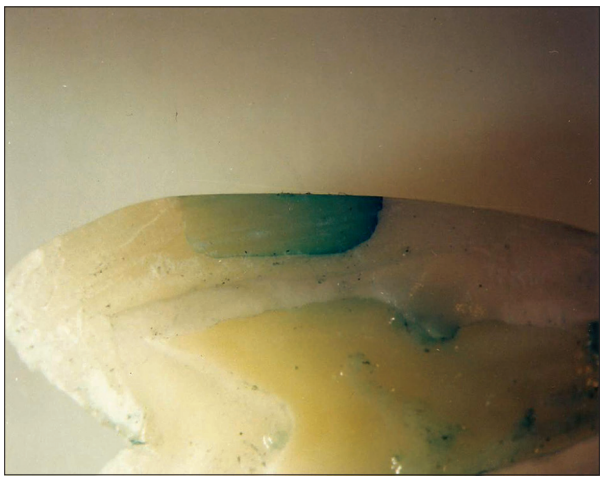


Figure 1: Microleakage at tooth restoration interphase showing score 0 leakage at enamel and score 1.5 leakage at cemental margin.

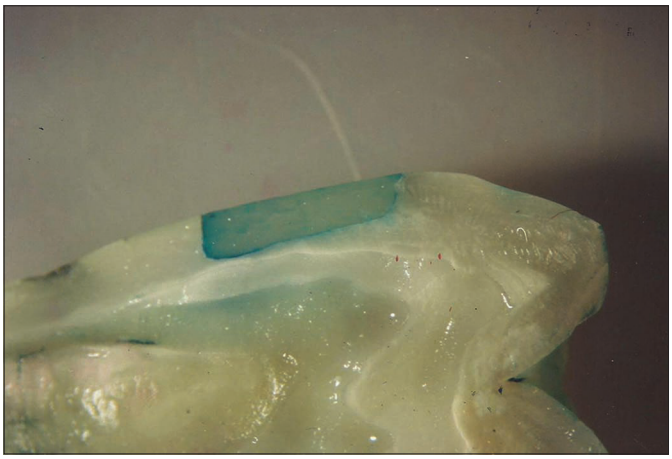


Figure 2: Microleakage at tooth restoration interphase showing score 2 leakage at both enamel and cemental margin.

Table 4: One-way ANOVA comparing micro leakage scores of compomer, conventional, and resin-modified glass-ionomer restorations along incisal and cervical margins in various media.

Margin	Material	Mean±SD					*F*	*P*
		Tea	Coffee	Coca-Cola	Lime	Saline		
Incisal	Dyract®	0.2500±0.3780^{b}	0.1875±0.3720^{b}	0.4375±0.4955^{b}	0.5625±0.4955^{b}	0.000±0.000^{a}	2.850	<0.05
	Fuji II	0.7500±0.4629^{a}	0.8125±0.3720^{a}	1.4375±0.6781^{b}	1.5825±0.6781^{b}	0.5000±0.5345^{a}	5.486	<0.01
	Fuji II LC improved	1.0000±0.4629^{b}	0.8750±0.4432^{b}	1.5000±0.5345^{c}	1.8750±0.2315^{c}	0.5000±0.5345^{a}	9.233	<0.01
Cervical	Dyract®	0.7500±0.5345^{b}	0.7500±0.5345^{b}	0.8750±0.4432^{b}	1.0625±0.4173^{b}	0.1250±0.3536^{a}	4.657	<0.01
	Fuji II	1.2500±0.4629^{a}	1.2500±0.4629^{a}	1.8750±0.2315^{b}	2.000±0.000^{b}	1.0625±0.1768^{a}	13.757	<0.01
	Fuji II LC improved	0.5000±0.5345^{a}	0.5000±0.5345^{a}	1.000±0.000^{b}	1.3750±0.5825^{b}	0.1250±0.3536^{a}	11.284	<0.01

Mean with the same superscript do not very significantly (DMRT), ANOVA: Analysis of variance, DMRT: Duncan multiple range test, SD: Standard deviation

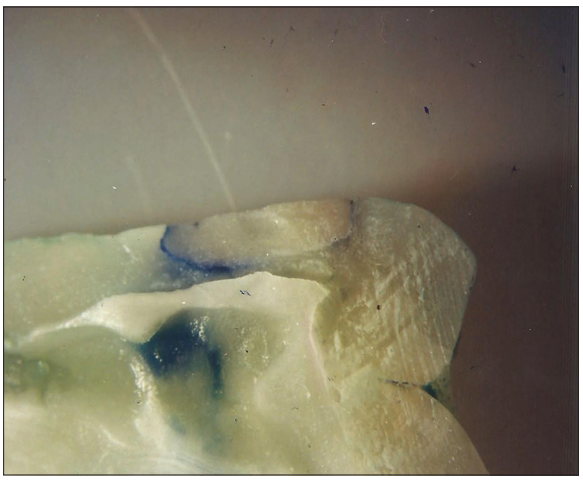
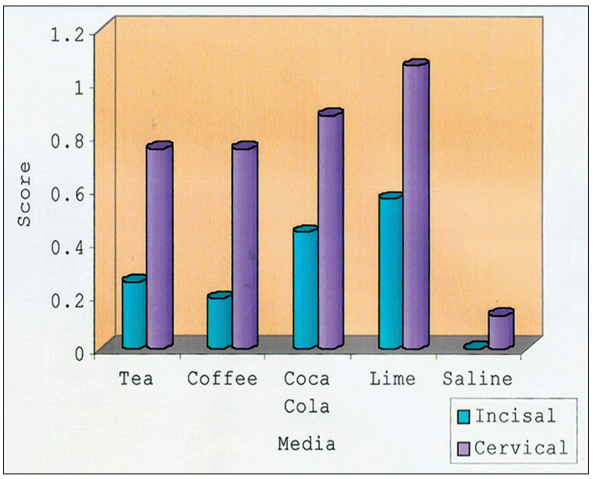
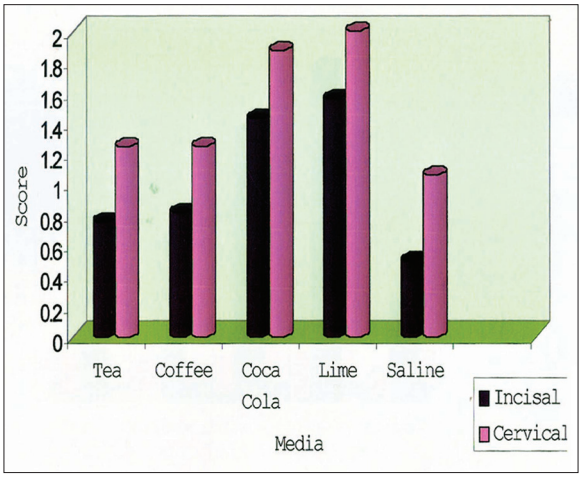


Figure 3: Microleakage at tooth restoration interphase showing score 1 leakage at enamel and score 2 leakage at cemental margin.

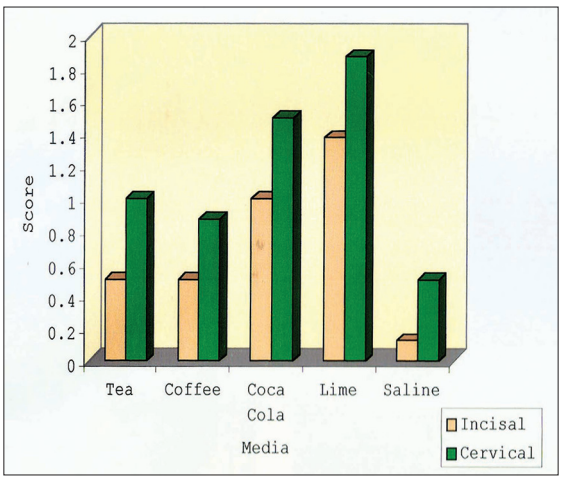


Graph 1: Microleakage of compomer restorations along enamel and cemental margins in different media.



Graph 2: Microleakage of conventional glass-ionomer restorations along enamel and cemental margins in different media

potential for mercury toxicity, tooth colored restorations have gained popularity.[9] The acidity or alkalinity of oral cavity



Graph 3: Microleakage of resin-modified glass-ionomer restorations along enamel and cemental margins in different media.

varies from around 4-8.5 while the intake of acidic fruit juices or alkaline medicament can extend this range from 2 to 11.

Commonly consumed soft drinks and fruit juices cause damage to the teeth due to their low pH and high titratable acidity leading to non-carious cervical tooth loss. The sugars in these drinks are metabolized by plaque microorganism to generate organic acids that bring about demineralization leading to dental caries. In the oral cavity, both dissolution of elements and erosion of the non-soluble components of the restorative materials occur. Numerous factors such as low pH, acidic foods, ionic composition, ionic strength of saliva, and enzymatic attacks are important parameters which may influence the quality and quantity of the substances released from a restorative material as well as its physical and mechanical properties.[10]

Micro leakage tests are the cheapest and fastest method to evaluate the sealing ability of restorative materials.[11] Drawbacks associated with the test are it is hard to reproduce all the challenges that a restoration face in the oral environment through this *in vitro* method.[12] Methylene blue dye was used for this study as it has a solubility in water, low molecular weight, no color changes during the test and lack of high transmission of incident light. Moreover, it has no tendency for bonding to teeth structure or restorative materials.[12] The molecular size of methylene blue is smaller than typical bacteria, and so it can penetrate deeper than any other dye.

Saline with pH 7 was chosen as a control for this study because of its natural condition and is usually the medium used for dental materials studies. Thermocycling was done to simulate the temperature changes in the oral cavity. Variation in oral temperature can cause contraction and expansion of both teeth and restorative material, and this may affect the adhesion between them because of the difference in coefficient of thermal expansion.

In the present study, the material Dyract® showed least micro leakage scores compared to Fuji II and Fuji II LC improved in all tested media and control group. No micro-leakage was seen along incisal margins for sub-Group I_E. Only one specimen of sub-Group I_D showed leakage score of 2 along cemental margin. 50% showed no leakage along the incisal margin for specimens in sub Group I_C but only 25% showed no leakage along incisal margin in sub-Group I_D, even though there was no statistically significant difference between these subgroups (I_D and I_C).

For Group II, the scores were higher than that of Dyract® 50% showed no leakage along incisal margin for the control group. 87% showed leakage score 2 along incisal margin, and 100% showed score 2 along cemental margins for specimens in sub-Group II_D. 75% showed leakage score 2 along incisal and cemental margins for restorations immersed in Coco-Cola. But there was no statistically significant difference between sub-Group II_D and II_C.

In Group III, about 87% showed no leakage along incisal margin and 50% showed no cemental micro leakage among specimens in Group III_E. 75% showed a score of 2 along cemental margin and 50% showed 1.5 score along incisal margin for restoration in subgroup III_D. In III_C 100% (all specimens) showed score 1 along incisal margin and 50% showed score 2 and remaining half showed score 1 along cemental margins. Here also, there was no statistically significant difference between the sub-Group III_C and III_D. In tea and coffee the leakage scores were more or less similar in all subgroups for the three materials. Among the tested materials, Fuji II had the greatest micro leakage compared to the other two materials. In the case of restorations of the three materials immersed in control media, saline the $P > 0.05$ when the leakage scores of the three materials were compared separately for incisal and cemental margins.

The single component system of Compomer (Dyract®) does not allow pockets of air to form in the material which may occur in case of two-component systems that require mixing. This can be the reason for the less leakage of Group I compared to Group II and III in this study.[13] Acid etching with phosphoric acid produces micro retentions on enamel that are then filled by fluid resin producing tags, resulting in adequate and long-lasting adhesion between the restorative material and the enamel. This may be the reason for the lower micro leakage scores of compomer in enamel compared to cemental margins for Group I in all the tested media and saline. Two different mechanisms are responsible for the formation of adhesive bonds to the cavity wall in case of Dyract®. Fifty percent of the reactive units of the TCB monomer in Dyract® consist of hydrophilic carboxyl groups. These carboxyl groups form ionic bonds with calcium ions of the tooth structure. Second mechanism is adhesion to the tooth surface through the primer/adhesive system.[5] Incorporated hydrophilic components of prime and Bond NT help to dislodge moisture from the conditioned dentin and attain an intimate interaction at the demineralized intertubular and peritubular dentin, creating hybrid layer essential for an ideal bond to dentin.[14] Studies comparing Class V Dyract restorations on etched and nonetched human teeth have shown that etched specimens demonstrated significantly less micro leakage compared to nonetched specimens.[15]

Peutzfeldt investigated the bond strengths of compomer and glass-ionomer cements to dentin and found that the compomers bonded stronger than resin-modified and conventional glass-ionomer materials.[16] The results of the present study show similar finding. More leakage was observed in Group II compared to resin-modified glass-ionomer restorations in this study which is similar to the results in another study.[17] In case of Fuji II LC improved, because of the slowness of the acid-base reaction in the cement, polycid is available for a longer period resulting in the formation of a stronger adhesive bond compared to Fuji II.[17] The bonding mechanism of resin-modified and conventional glass-ionomers rely on the presence of calcium. Hence, the dentin or cementum margins of these restorations show weak marginal adaptation and hence higher micro leakage.[18] This may be the reason for the lower micro leakage scores along enamel margins for both Group II and III in all test media and control, compared to cemental margins.

The acidic properties of acids are determined by the amount of acid available (titratable acidity) and the amount of acid actually present (concentration of H^+ ions).[19] Type of acid, titratable acidity, buffering capacity, and temperature influence the dental erosive capacity of acidic liquids.[20] Carbonated drinks get neutralized early despite having a lower pH than fruit drinks.[21] In cola drinks, phosphoric acid is normally used but citric acid predominates in fruit juices and non-cola drinks. Studies have shown that citric acid causes more erosion than phosphoric acid.[22] This could be the reason for more micro-leakage of all the three tested materials in lime juice compared to Coca-Cola. Frequent consumption of low pH beverages showed erosion of the enamel in both *in vivo* and *in vitro* studies.[23,24] It is quite possible that the higher micro leakage scores seen in low pH media in the present study can be due to the restorative materials being removed along with the hard tissues by these drinks.

The results of this *in vitro* study provides some insight concerning the performance of the three restorative materials, which are widely accepted for restoring cervical lesions in the oral environment. But this *in vitro* study has several limitations since these restorations are prone to more kinds of stress in the oral cavity which are not tested in the present study and which may further deteriorate these restorative materials. Moreover, the entire variables faced by such restorations during *in vivo* performance cannot be included in this study.

Conclusion

Within the limitation of the present study, it can be concluded that among the three restorative materials tested Dyract® was found to have better marginal adaptation to both cementum and enamel followed by Fuji II LC improved and then Fuji II. The three materials showed better adaptation to enamel margin than to cemental margins. Fruit juice (lime juice) was found to increase the micro leakage for all three materials followed by Coca-Cola, tea and coffee, and then saline. But there was no statistically significant difference noted between lime juice and Coca-Cola immersion groups for three materials. Further clinical researches are needed to detect the influence of other types of stresses on these restorative materials. The results of this study indicate that dietary counseling regarding reducing the intake of acidic foods and drinks is essential along with restorations, for managing cervical lesion and preventing new occurrences of such lesions. Regular recall checkups are needed for evaluating the integrity of such restorations.

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