MICROLEAKAGE IN NEW RESIN-MODIFIED GLASS IONOMER CEMENTS USING NEW NO-RINSE CONDITIONERS: AN *IN-VITRO* STUDY

by

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INTRODUCTION

Glass-ionomer cements (GIC) are materials, which undergo setting through an acid-base reaction of ion-leachable glass with an aqueous polyacid and are characterized by properties such as brittleness, adhesion, and fluoride release.[1] Glass ionomer cement was introduced to dentistry in 1970 by Wilson and Kent[2] with the goal of combining the advantages of silicate and polycarboxylate cements. However, difficulty with manipulation and poor mechanical properties compared with other materials jeopardized their initial success. The advantages of glass ionomer such as chemical bonding to tooth structure and lower microleakage compared with resins prompted researchers to continue working to further improve the material.[3,4,5]

Conventional glass ionomer cements are a powder and liquid formulation.[6] Polyalkenoic acid is the main component of the liquid and the powder is fluoroaluminosilicate glass. When the powder and liquid are mixed, an acid base reaction occurs leading to the formation of polyalkenoate salts. This leads to gelation, which progresses until the cement sets.[7]

In the late 1980s the first resin-modified glass ionomer cement (RMGIC) was introduced in an attempt to improve the properties of glass ionomers.[8] The addition of small amounts of resin improved many of the physical properties of glass ionomer cement while retaining its advantages.

Recently, both 3M and GC America introduced paste/paste resin modified glass ionomer cement systems. Ketac Nano from 3M was introduced claiming improved esthetic properties.[9] Fuji Filling LC from GC America was launched based on better

esthetic and superior adhesion data.[10,11] Increased amounts of resin monomers added to the glass ionomer may be responsible for the improved physical and optical properties.[5] For these new paste-paste systems both manufacturers state the necessity to use new pretreatment conditioners instead of the conventional polyacrylic acid. Ketac Nano uses 3M Ketac Nano Primer and Fuji Filling LC uses GC Self Conditioner as a pretreatment.[12,13] Both new conditioners appear to be acidified resins. The manufacturers also suggest that these new pretreatments can be used with their respective conventional and resin-modified glass ionomer cements. The concern is that these materials may be bonding to tooth structure via resin bonding instead of traditional glass ionomer chemical bonding.

Currently available resin-modified glass ionomer cement provides optimal sealing at the margins of restorations.[4,14,15] Studying the microleakage is very important for determining the success of restorative materials. Evidence is needed to prove the superiority of the bond to tooth structure of these relatively new paste-paste glass ionomer systems when used in combination with the new conditioners.

The purpose of this study was to compare the degree of microleakage at the tooth restoration interface using polyacrylic acid or the new non-rinse conditioners for placing powder liquid and paste/paste RMGIC restorations.

NULL HYPOTHESIS

There would be no significant difference in microleakage when using polyacrylic acid or the respective non-rinse dentin conditioner with Ketac Nano, Fuji Filling LC, Photac Fil, and Fuji II LC.

REVIEW OF LITERATURE

Over the last decades, the prevalence and severity of dental caries has declined, and decay patterns have changed with occlusal surfaces being most often affected.[16] This reduction in dental caries was achieved with the help of newer and better materials for caries prevention and treatment. The ability to release fluoride,[17] providing a potential cariostatic and antimicrobial action,[18] makes GIC and RMGIC more suitable for restoration of carious lesions.[19,20] Kotsanos [21] found that GIC and RMGIC release fluoride provides protection against secondary decay. Wiegand [22] and Berg [23] proved in their studies that fluoride release helps to prevent demineralization of adjacent calcified tissue. The mechanism of fluoride release varies, being primarily ion exchange in some products while dissolution occurs in other products.[24] There is no convincing evidence of the levels of fluoride required to produce a therapeutic effect. It has been shown that a resin-modified glass ionomer has caries inhibition properties equivalent to that of conventional glass ionomer when tested *in vitro*.[25] RMGIC restorations in carious or non-carious lesions appear to resist or inhibit the development of caries for up to five years. Surprisingly, this is in spite of the apparent deterioration of marginal adaption over time that can lead to microleakage and eventually secondary caries.[26,27] This shows that even though the amount of fluoride released by RMGIC is not high, it has considerable therapeutic effect.

Chemical bonding to enamel and dentin is another key feature of glass ionomer cement. This is achieved without the use of phosphoric acid and adhesive application.[28,29] Bond strengths of RMGIC to dentin are generally greater than those for conventional

GIC. Bonding efficacy has been demonstrated using both bond strength and leakage studies.[30,31,32] Bonding to superficial dentin is stronger compared with deep dentin, just as for most dentin bonding agents.[33] However, there is not enough evidence as yet to support the hybrid layer formation for these products, although ion exchange between dentin and RMGIC material has been observed using secondary ion mass spectrometry.[34] The bonding mechanism of RMGIC has been reported to be both an ionic interaction between the cement and the dentin surface and a micromechanical interlocking of the polymer with the polyacrylic acid-conditioned tooth substrates.[35]

Retention in modern restorative materials is dependent on a material's adhesion to tooth structure using mechanical and chemical bonding. This makes retention one of the most important criteria often used to determine the longevity of the restoration. Different studies done by Neo, Gladys, Flowaczny and Louguercio demonstrated little variation in retention rates despite different sample size, duration of observation, and products investigated. All RMGIC products used in these studies showed good retention in non-carious class V lesions.[30,36,37,38,39]

Material deterioration is another parameter affecting the longevity of a restoration. In a mid-to-long term study, Neo, Flowaczny, and Loguercio showed that RMGICs do not perform as well as composite resins when it comes to surface texture, contour and wear.[38,39,40]

Color stability and color match are other factors influencing the choice of restorative material. Maneenut, Flowaczny and Loguercio found in their respective studies of 1 year, 3 years, and 5 years that RMGIC has poor color stability over time. This could be related to changes within the material manifested as wear and loss of

anatomic form.[40,42] Resin composite has superior esthetic properties compared with RMGIC and GIC due to overall longer color stability and less wear. Composite resins are esthetically superior and they have better finishing and polishing properties compared with RMGIC and GIC.[40,41]

The pulpal and biological effects of all restorative materials are important to their clinical usage. RMGIC had acceptable biocompatibility to pulpal and periodontal tissues in the studies done by Stanley and Sidhu.[42,43] Van Dijken found in his study that only nine out of 274 restorations caused post-operative sensitivity.[44] In another study, large class III restorations did not show any post-operative sensitivity or change in pulpal vitality.[45] In the absence of more long-term clinical data, it is not possible to arrive at a definite conclusion about the long-term effect of RMGIC when in direct or indirect contact with pulpal tissue. A relatively recent review of biocompatibility of RMGIC used in dentistry showed that RMGIC has acceptable biocompatibility but is not as biocompatible as conventional glass ionomer cement.[46]

Croll, [47] Mitra [48] and Wilson [49] found that RMGIC is more tolerant of moisture than resin materials making them less technique-sensitive compare with resin. Hickel [50] and Tyas [51] showed that the coefficient of thermal expansion for RMGIC is similar to dentin's and that the setting contraction is less than values recorded for resin composite.

Dijken [52] and Fritz [53] concluded in their studies that when it comes to mechanical properties and surface integrity, RMGICs are not as good as resin composite. In another long-term study done by Sidhu and Fritz, composite showed superior mechanical performance and surface integrity compared with GIC and RMGIC.[54,5] Gladys and colleagues found in their literature review that microhardness of RMGIC is lower than

restorative resins and dentin and that they should not be used for posterior occlusal restorations.[55]

Microleakage has been recognized as one of the problems, which contributes to the failure of the restorative material used. Different methods of measuring microleakage are used to determine the predictive outcome of the tooth restoration interface against the passage of bacteria, molecules, ions, chemicals and fluids. Microleakage has been implicated in various conditions including but not limited to pulpal response, post-operative sensitivity, secondary caries, and breakdown of certain filling materials leading to the failure of restorations.[56,57]

Different microleakage measurement techniques have been used for many years. Most modern techniques utilize various biological, chemical, electrical, physical, or radioactive components. Dyes, radioactive isotopes, bacteria, scanning electron microscopes, artificial caries, air pressure, and calcium hydroxide are some examples.[58,59] Different methods have their own advantages and disadvantages. It is assumed that different microleakage methods will give similar results, but this has not been shown to be the fact.[60,61]

Currently used microleakage measuring methods are based on penetration. This includes preparation and filling of the cavity, then immersion of the samples into a tracer for penetration. Specimens are then cleaned, sectioned, and examined under a microscope. The use of organic dyes is one of the oldest and most popular techniques of microleakage analysis. [62]

Microleakage measurement is done in many studies using different materials and methods. So far, no definitive conclusion has been made regarding which material or

method is superior. A recent study by El Halim and Zaki concluded that all glass ionomer cements will eventually show some leakage depending on immersion time. In their study, Photac Fil Quick glass ionomer showed maximum leakage, followed by Vitremer. Ketac N100 showed the least leakage.[63] Complete resistance to microleakage was not shown in any glass ionomer cement using different cavity preparation methods, and a significant difference was associated with gingival and occlusal margins. Gingival margins showed more microleakage compared with occlusal margins in all restorative formulations of Fuji glass ionomer cement. Fuji II LC showed the least microleakage.[64]

Some studies compared postoperative sensitivity and reported very few cases of postoperative sensitivity when RMGIC was used.[65,66]

Various studies show that RMGICs self-adhere to dental substrate but the adhesion level was significantly lower than resin composite restorations bonded with the use of an adhesive system.[67,68,69] Considering these results, researchers bonded RMGIC to dental substrate using self-etching adhesive systems. Their results showed improvements in bond strength.[72,70] A recent study by Sabine concluded there was no significant difference among three self-etch adhesive systems. The study also concluded that treating the dentin with a self-etch adhesive before placement of RMGIC restorations can be used as an alternative to the conventional polyacrylic acid conditioning. This is in agreement with previous microtensile bond testing.[52]

In general, RMGIC shows better performance when it comes to retention. In addition, post-operative sensitivity and secondary caries are not a concern with RMGIC. However, their surface properties, color stability, and marginal characteristics do not always show promising results.[5]

METHODS AND MATERIALS

The microleakage of four different restorative materials was measured following two different substrate conditioning protocols in this *in vitro* study (Table I). Photac Fil with Ketac cavity conditioner (Group 4) and Fuji II LC with GC Cavity Conditioner (Group 8) were used as controls. Composition of these restorative materials and respective pretreatment are in Table II, Table III(a), and Table III(b).

Ninety-six extracted human molars were used. The teeth were hand-scaled, cleaned, and stored in distilled water at 23±2ºC for a minimum of 12 hours prior to use (Following ISO/DTS 11405 guidelines). A standardized Class V cavity preparation was placed on the buccal surface of each tooth with a high-speed handpiece, using copious water spray and an #56 carbide bur (Alpine). The bur was changed after every two cavity preparations. The cavity dimensions were 2±0.2 mm occluso-gingivally by 3±0.2 mm mesio-distally, and 2±0.2 mm in depth.[52,71] The cavity preparation was measured using a periodontal probe. The preparations were centered on the cementoenamel junction (CEJ) keeping the occlusal margin on enamel and gingival margin on cementum-dentin (Figure 2). The teeth were randomly divided among the eight restorative groups (n=12) (Table I). In Group 1, 3, 4, 5, 7, and 8 the cavity preparations were conditioned following manufacturer recommended protocols prior to restoration placement. Conversely, the cavity preparations in Group 2 and Group 6 were conditioned with polyacrylic acid contrary to manufacturers' recommendations. All pretreatments were applied to cavity surfaces using microbrushes. The restorations were light-cured using an Optilux 400 light cure unit (Demetron Research Corp, Danbury, CT). The output of the curing light was

monitored before the beginning for each group using a Demetron radiometer (model 100, Demetron Research Corp.) to maintain a >600 mw/cm^2 light output. Immediately after curing, all the restorations were contoured and polished using conventional finishing and polishing instruments, (e.g., Sof-LexTM Finishing and Polishing System, #15 surgical blade) under moist conditions. Care was taken to prevent desiccation of the restoration surface.

Group 1: Ketac Nano primer was applied to the cavity preparations for 15 seconds. An air syringe was used to thin out the primer followed by light curing with an Optilux 400 curing light for 10 seconds. Ketac Nano shade A2 was applied following manufacturer's instructions. The restoration was light cured for 20 seconds followed by finishing and polishing as previously described.[14]

Group 2: The cavity preparations were conditioned with Ketac conditioner for 10 seconds followed by rinsing with copious water until all of the conditioner was removed. The cavity was lightly air-dried for 5 seconds to avoid desiccation. Ketac Nano was then placed, light-cured, finished, and polished as previously described.

Group 3: Cavity preparations were treated with Ketac Nano primer as per in Group 1. Photac Fil quick applicap shade A2 was then activated, mixed for 10 seconds at 4300 rpm high frequency in a Kerr Automix computerized mixing system, and applied following manufacturer's instructions. Finishing and polishing were performed as previously described.[72]

Group 4: The cavity preparations were conditioned using Ketac conditioner as in Group 2. Photac Fil was activated, mixed, and applied as described in Group 3. Finishing was performed as discussed earlier.[76]

Group 5: GC Self Conditioner was applied to the cavity preparations, left undisturbed for 10 seconds, and then lightly air-dried for 5 seconds to avoid desiccation. Fuji Filling LC was dispensed onto a mixing pad. Paste A and Paste B were hand-mixed for 10 seconds following manufacturer's instructions. The cavity was then filled using a resin composite hand instrument and light-cured for 20 seconds. Finishing was performed as previously described.[15]

Group 6: The cavity preparation was conditioned with GC Cavity conditioner for 10 seconds followed by rinsing the cavity thoroughly with water and gently drying to avoid desiccation. The cavity was then filled with Fuji Filling LC, light-cured, and finished as in Group 5.

Group 7: Cavity preparations were conditioned using GC Self Conditioner as in Group 5. Fuji II LC capsules were then activated and mixed for 10 seconds at 4000 rpm at high intensity using Kerr Automix as previously mentioned. Cavities were then filled with Fuji II LC and light-cured for 20 seconds following the manufacturer's instructions. Finishing was performed as previously described.

Group 8: Cavity preparations were conditioned using GC cavity conditioner as described in Group 6. Fuji II LC was then placed, light-cured, and finished as in Group 7. Restored teeth were stored in 100-percent humidity at 37±2°C for 24 hours before thermocycling (following ISO/DTS 11405 guidelines). Specimens were thermocycled for 500 cycles between water baths at 6°C and 48°C with a dwell time of 30 s and a transfer time of 10 s. After thermocycling, the root apex of each tooth was sealed using Loctite Super glue and the teeth were coated with NYC long-wearing nail enamel to within 2 mm of the restoration margins. The teeth were then immersed in 2.0-percent methylene blue

(manufactured by IBI) and stored at room temperature for 24 hours.[73] After immersion, the teeth were washed with running tap water for 30 s. The specimen groups were blinded and identified as Groups A through H. Next, the teeth were embedded in acrylic resin and sectioned with a diamond saw with water cooling (Isomet, Buehler, Lake Bluff, IL). A 1-mm thick section was taken from the center of each restoration (Figure 3). The occlusal and gingival margins of each section were examined with a stereomicroscope at X10 magnification to determine the degree of microleakage. Both sides of the specimen section were examined at the occlusal and gingival margins making a total two (2) occlusal and two (2) gingival microleakage scores for each section. The greatest occlusal and the greatest gingival scores were used as the microleakage scores for that specimen (Figure 1).

The following scoring system was used[74] (Figure 4):

0 = No leakage.

1 = Penetration up to the middle half of the occlusal or cervical cavity wall (Figure 5).

2 = Penetration beyond the middle half of the occlusal or cervical cavity wall but not to the axial wall (Figure 6).

3 = Penetration including the axial wall (Figure 7).

STATISTICAL METHODS

Microleakage was summarized (mean, standard deviation, standard error) by pretreatment/material combination for occlusal and cervical surfaces. Mixed-model ANOVA was used to compare the effects of pretreatment/material and surface location

on microleakage. A random effect was included in the ANOVA because of the within-tooth correlation between the occlusal and cervical surfaces.

RESULTS

The microleakage score at the occlusal and cervical margins of each sample were used for statistical calculation (Figure 1). Mixed-model ANOVA was used to test the fixed effect of the eight groups (Table I) and cervical vs. occlusal location within each tooth sample on microleakage, with sample as the random effect. Both main effects and the interaction were significant $p<.0001$ for both group and location effects, and $p = 0.0013$ for the interaction of group and location (Table V).

The location difference was significant in Group 1 (Ketac Nano with Ketac Nano Primer), Group 2 (Ketac Nano with Ketac Conditioner), Group 5 (Fuji Filling LC with GC Self Conditioner) and Group 7 (Fuji II LC with GC Self Conditioner) (Table IV), with cervical locations having more microleakage than occlusal margins.

For the occlusal margins, all groups performed well, and there was no significant difference in microleakage among the groups (Table IV, Figure 8), though control group 4 (Photac Fil with Ketac conditioner) and Group 8 (Fuji II LC with GC Cavity Conditioner) showed the least mean value among all groups.

For cervical margins, Group 8 (Fuji II LC with GC cavity conditioner) showed the lowest mean score followed by Group 3 (Photac Fil with Ketac Nano Primer), Group 4 (Photac Fil with Ketac Conditioner) and Group 6 (Fuji Filling LC with GC Cavity Conditioner) (Table IV, Figure 8). For cervical locations, Group 2 (Ketac Nano with Ketac conditioner) was significantly different from Group 3 (Photac Fil with Ketac Nano Primer), Group 4 (Photac Fil with Ketac Conditioner), Group 6 (Fuji Filling LC with GC Cavity Conditioner) and Group 8 (Fuji II LC with GC Cavity Conditioner) (Figure 9);

Group 3 (Photac Fil with Ketac Nano Primer) was significantly different from Group 1 (Ketac Nano with Ketac Nano primer) and Group 5 (Fuji Filling LC with GC Self-Conditioner) (Figure 10); Group 8 (Fuji II LC with GC Cavity Conditioner) was significantly different than Group 1(Ketac Nano with Ketac Nano primer), Group 5 (Fuji Filling LC with GC Self Conditioner) and Group 7 (Fuji II LC with GC Self Conditioner) (Table V and Figure 11).

On the cervical interface Group 3 performed the worst followed by Group 1, Group 5 and Group 7. On the occlusal interface Group 2 performed worst followed by Group 6 and Group 1.

TABLES AND FIGURES

TABLE I

Materials used and dentin pretreatments

GROUP	MATERIAL (MANUFACTURER)	PRETREATMENT
1	Ketac Nano (3M) Shade A2 (Lot # N264728)	Ketac Nano Primer (Lot #N265383)
2	Ketac Nano (3M) Shade A2 (Lot # N264728)	Ketac Cavity Conditioner (Lot # 431890)
3	Photac Fil (3M) Shade A2 (Lot # 424950)	Ketac Nano Primer (Lot #N265383)
4	Photac Fil (3M) Shade A2 **Control** (Lot # 424950)	Ketac Cavity Conditioner (Lot # 431890)
5	Fuji Filling LC (GC America) Shade A2 (Lot # 1010061)	GC Self Conditioner (Lot # 1011151)
6	Fuji Filling LC (GC America) Shade A2 (Lot # 1010061)	GC Cavity Conditioner (Lot # 1103251)
7	Fuji II LC (GC America) Shade A2 (Lot # 1009221)	GC Self Conditioner (Lot # 1011151)
8	Fuji II LC (GC America) Shade A2 **Control** (Lot # 1009221)	GC Cavity Conditioner (Lot # 1103251)

TABLE II

Pretreatment composition

Material	Component	Weight %
Ketac Nano Primer	Hydroxyethyl Methacrylate (HEMA)	35-45 %
	Water	40-50 %
	Copolymer of Acrylic and Itaconic acids	10-15 %
GC Self Conditioner	Ethanol	28-40 %
	Distilled Water	30-35 %
	Copolymer of Acrylic and Itaconic acids	20-30 %
	4-Methacryloxyethyltrimellitate anhydride	
Ketac Conditioner	Water	70-80 %
	Polyacrylic acid	20-30 %
GC Cavity Conditioner	Polyacrylic acid	20 %
	Distilled water	77 %
	Aluminum chloride hydrate	3 %
	Food additive Blue No. 1	< 0.1 %

TABLE III (a)

RMGIC composition

Material	Types	Component	Wt %
Ketac Nano	Paste A	Silane treated glass	40-55 %
		Silane treated zirconia	20-30 %
		Polymethylene glycol dimethacrylate (PEGDMA)	5-15 %
		Silane treated silica	5-15 %
		2-Hydroxyethyl methacrylate (HEMA)	1-15 %
		Glass powder	< 5 %
		Bisphenol a diglycidyl ether dimethacrylate (BISGMA)	< 5 %
		Triethylene glycol dimethacrylate (TEGDMA)	< 5 %
	Paste B	Silane treated ceramic	40-60 %
		Copolymer acrylic and Itaconic acids	20-30 %
		Water	10-20 %
		2-Hydroxyethyl methacrylate (HEMA)	1-10%
Fuji Filling LC	Paste A	Alumino-silicate glass	75-85 %
		2-Hydroxyethyl methacrylate	10-12 %
		Urethanedimethacrylate	2-5 %
	Paste B	Distilled water	20 -30 %
		Polyacrylic acid	20- 30 %
		Urethanedimethacrylate	12-15 %
		Silicone dioxide	10-15 %

TABLE III (b)

RMGIC composition

Material	Types	Component	Wt %
Fuji II LC	Powder	Alumino-silicate glass	100 %
	Liquid	Polyacrylic acid	20-22%
		2-Hydroxyethyl methacrylate	35-40 %
		Proprietary Ingredient	5-15 %
		2,2,4, Trimethyl hexamethylene dicarbonate	5-7 %
		Triethylene glycol dimethacrylate	4-6 %
Photac Fil	Powder	Glass Powder	> 99 %
	Liquid	Polyethylene Polycarbonic acid	30-50 %
		2-Hydroxyethyl Methyethyl Methacrylate	25-50 %
		Water	20-30 %
		Diurethane Dimethacrylate	3-10 %
		Magnesium Hema Ester	5-10 %

TABLE IV

Descriptive statistics of outcome variable – microleakage

Group	Location	N	Mean	SD	SE
1	Cervical	12	2.8	0.6	0.2
	Occlusal	12	1.1	1.0	0.3
2	Cervical	12	3	0	0
	Occlusal	12	1.4	1.0	0.3
3	Cervical	12	1.2	1.4	0.4
	Occlusal	12	0.8	1.1	0.3
4	Cervical	12	1.5	1.6	0.5
	Occlusal	12	0.3	0.5	0.1
5	Cervical	12	2.8	0.9	0.3
	Occlusal	12	0.8	1.3	0.4
6	Cervical	12	1.5	1.0	0.3
	Occlusal	12	1.3	0.6	0.2
7	Cervical	12	2.3	1.2	0.4
	Occlusal	12	0.8	0.8	0.2
8	Cervical	11	0.7	0.9	0.3
	Occlusal	11	0.7	0.5	0.1

TABLE V

Mixed model ANOVA table

Effect	DF	F-value	P-value
Group	7	6.67	<.0001
Location	1	59.19	<.0001
Group*Location	7	3.79	0.0013

TABLE VI

Pair-wise comparisons – difference of cervical vs. occlusal

Group	Difference	SE	T-value	P-value
Group 1	1.75	0.39	4.48	0.0023
Group 2	1.58	0.39	4.05	0.0100
Group 3	0.33	0.39	0.85	1.0000
Group 4	1.25	0.39	3.20	0.1201
Group 5	1.92	0.39	4.91	0.0005
Group 6	0.18	0.41	0.45	1.0000
Group 7	1.58	0.39	4.05	0.0100
Group 8	0.00	0.41	0.00	1.0000

TABLE VII

Significant difference among groups – cervical

Group1-Group2	Difference	SE	T-value	P-value
Group 1- Group 3	-1.67	0.40	-4.15	0.0071
Group 1- Group 8	2.11	0.41	5.13	0.0002
Group 2- Group 3	1.83	0.40	4.57	0.0016
Group 2- Group 4	1.50	0.40	3.74	0.0271
Group 2 - Group 6	1.55	0.41	3.77	0.0249
Group 2- Group 8	2.27	0.41	5.54	0.0000
Group 3- Group 5	-1.58	0.40	-3.95	0.0142
Group 5- Group 8	-2.02	0.41	-4.93	0.0004
Group 7 - Group 8	1.61	0.41	3.91	0.0157

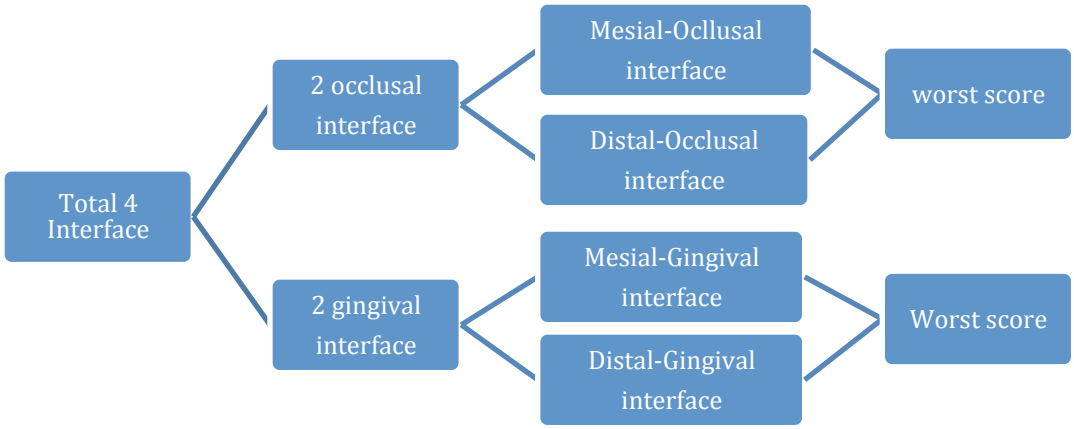


FIGURE 1. Scoring.

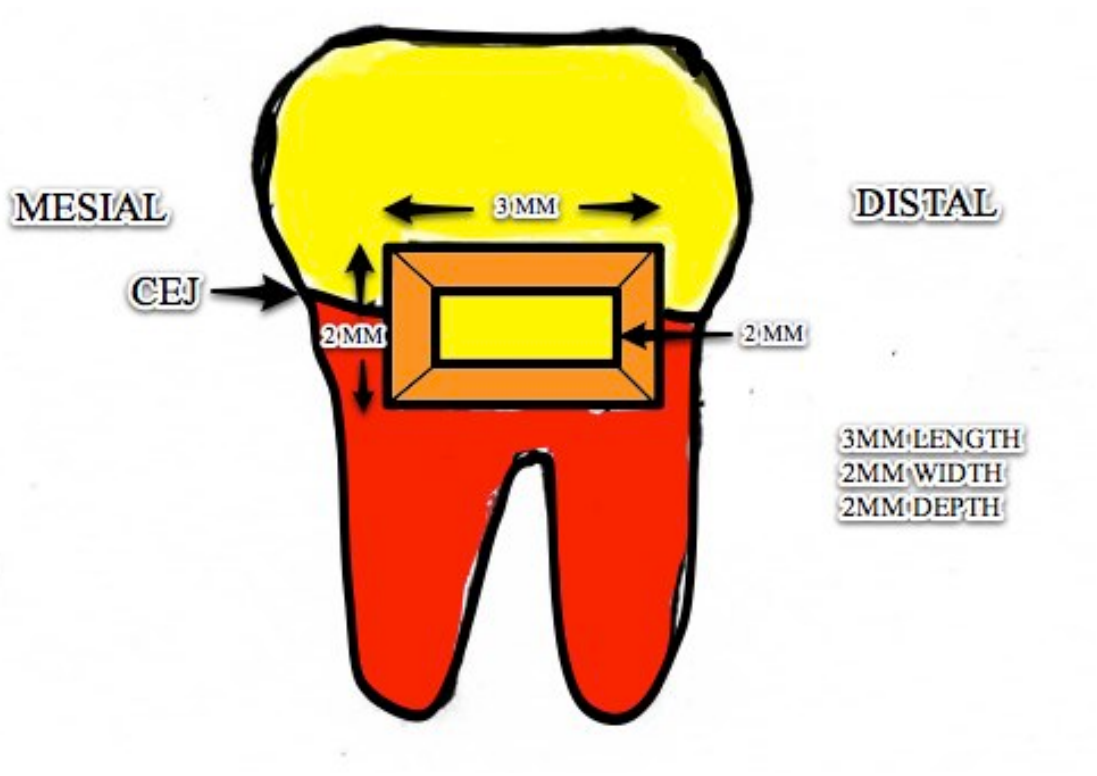


FIGURE 2. Cavity design.

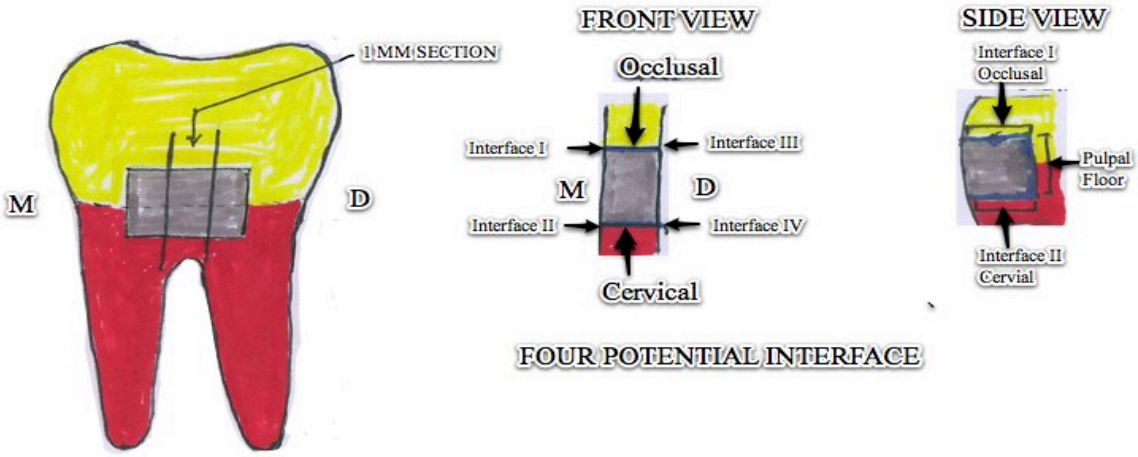


FIGURE 3. Section and interface between restoration and cavity.

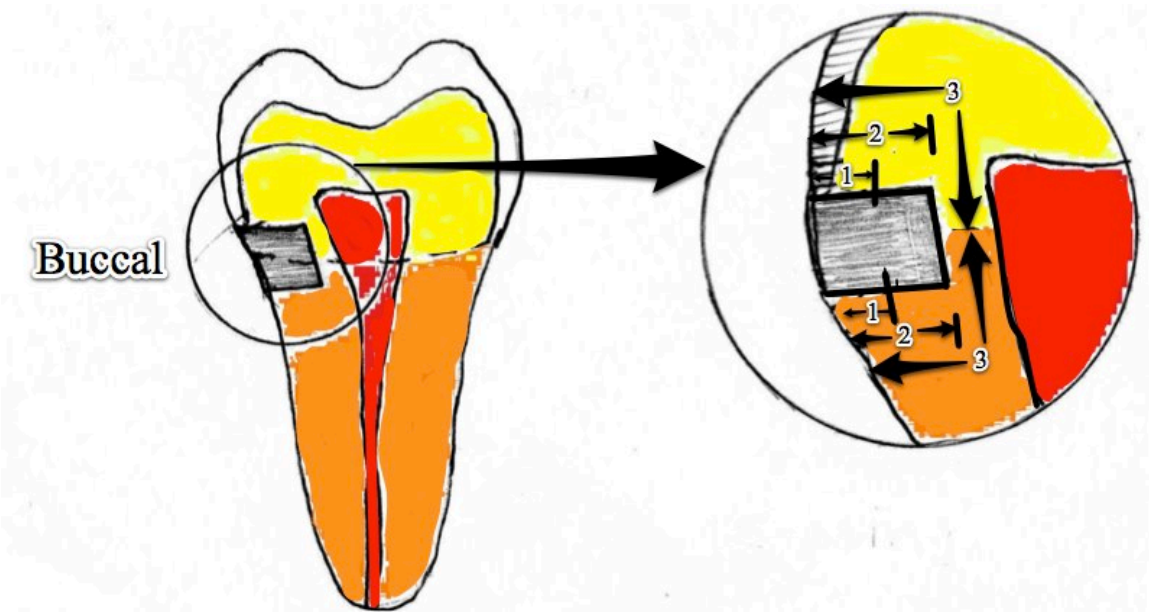


FIGURE 4. Scoring method.

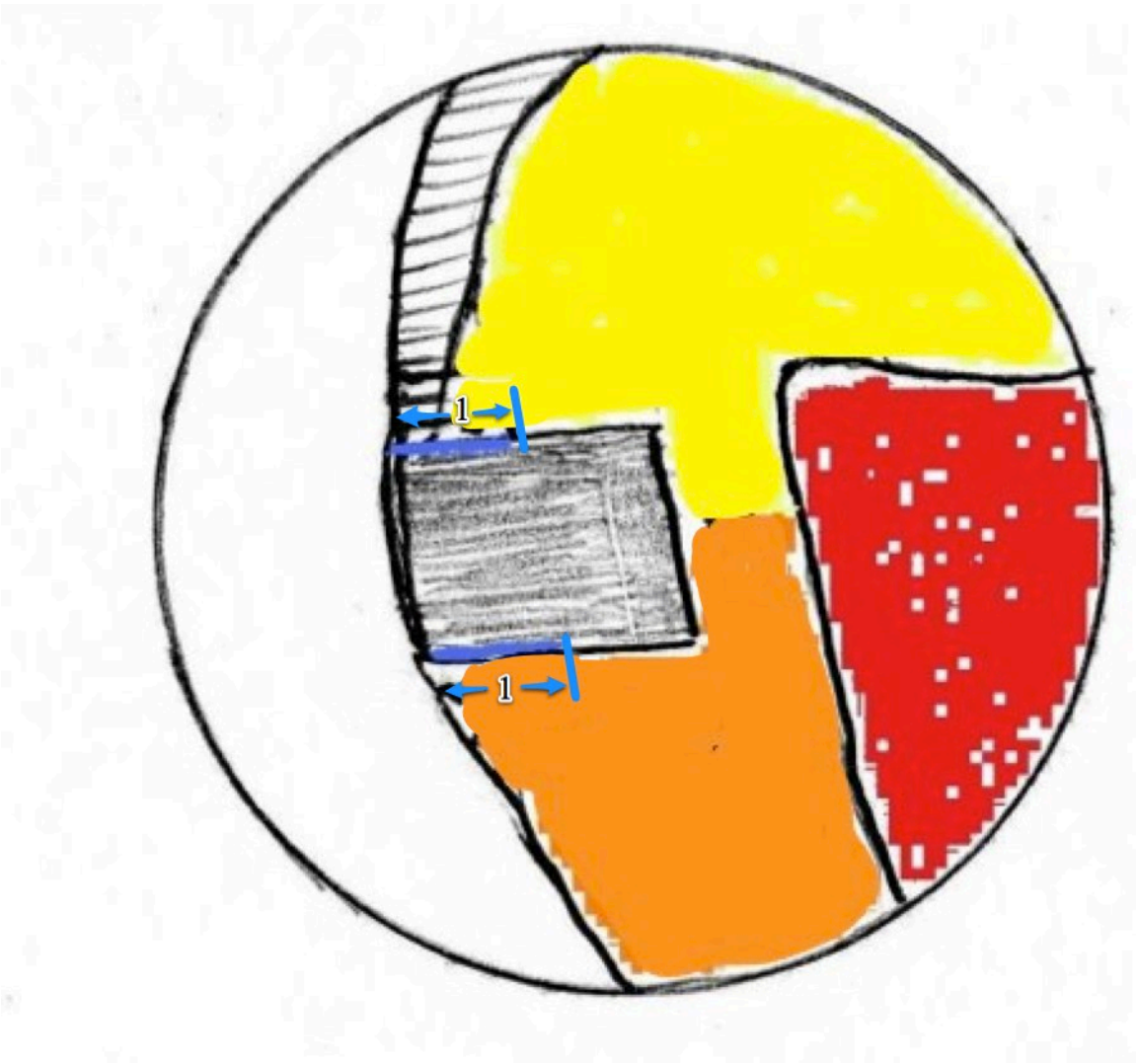


FIGURE 5. Score 1 methylene blue penetration.

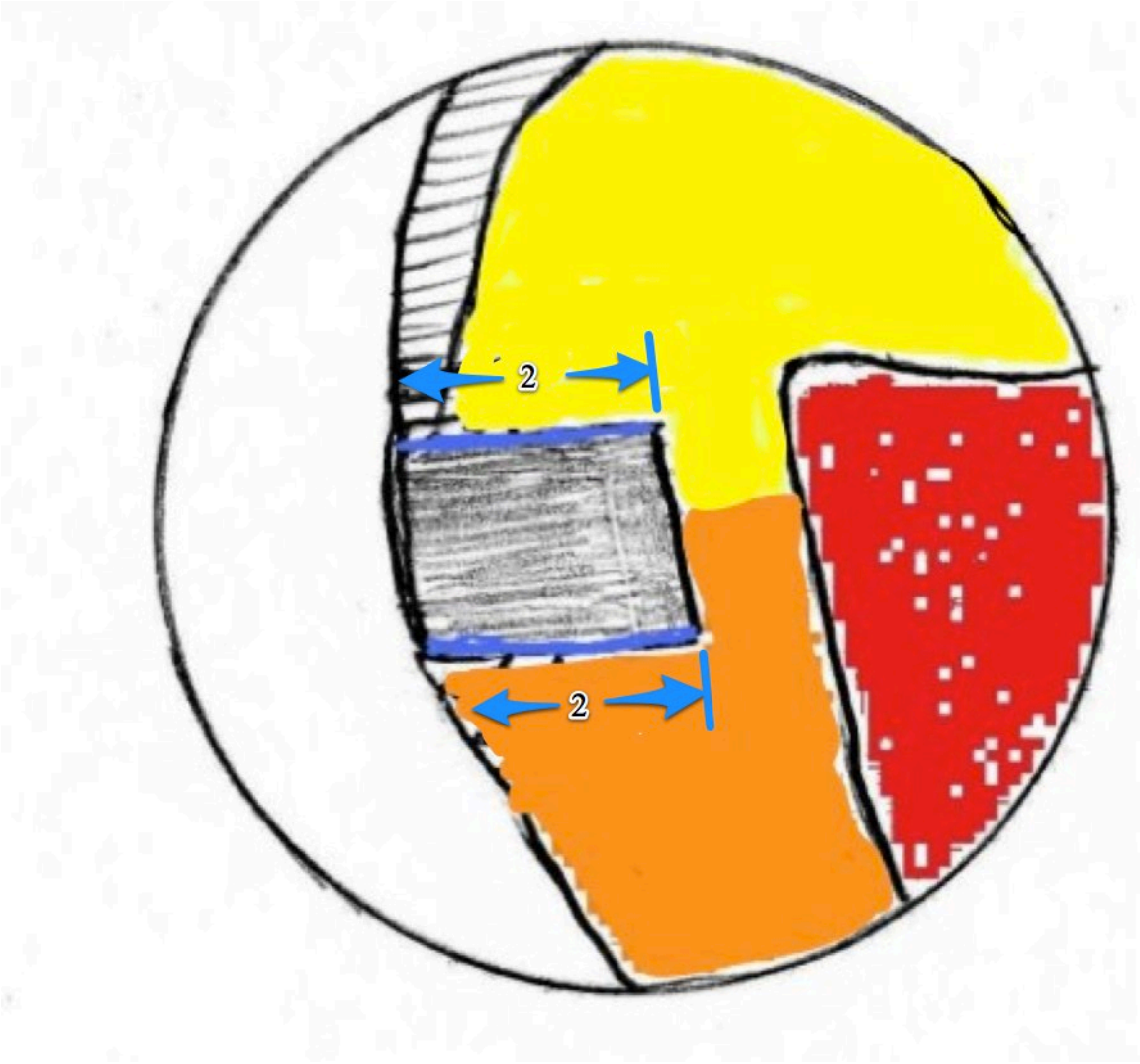


FIGURE 6. Score 2 methylene blue penetration.

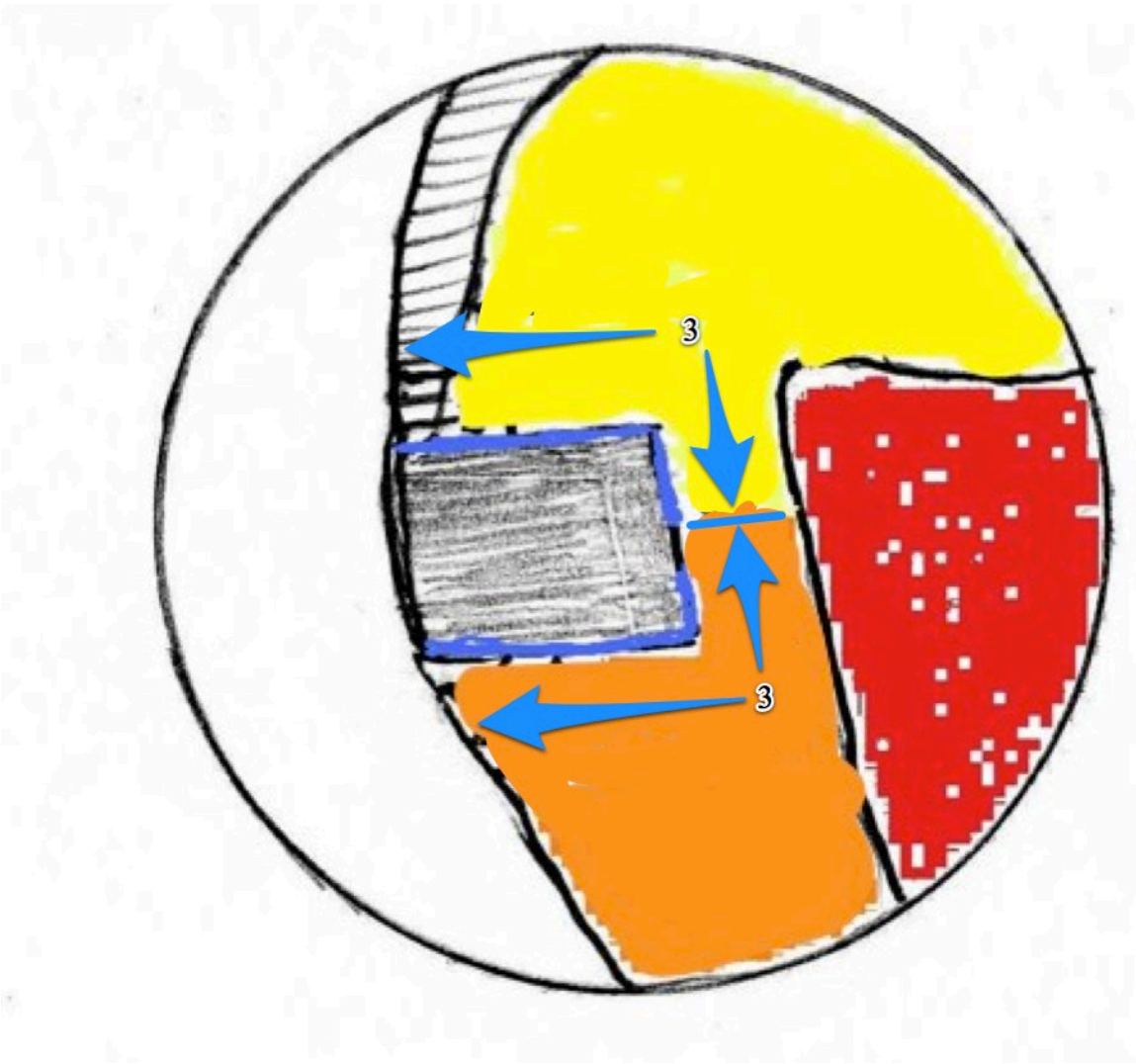
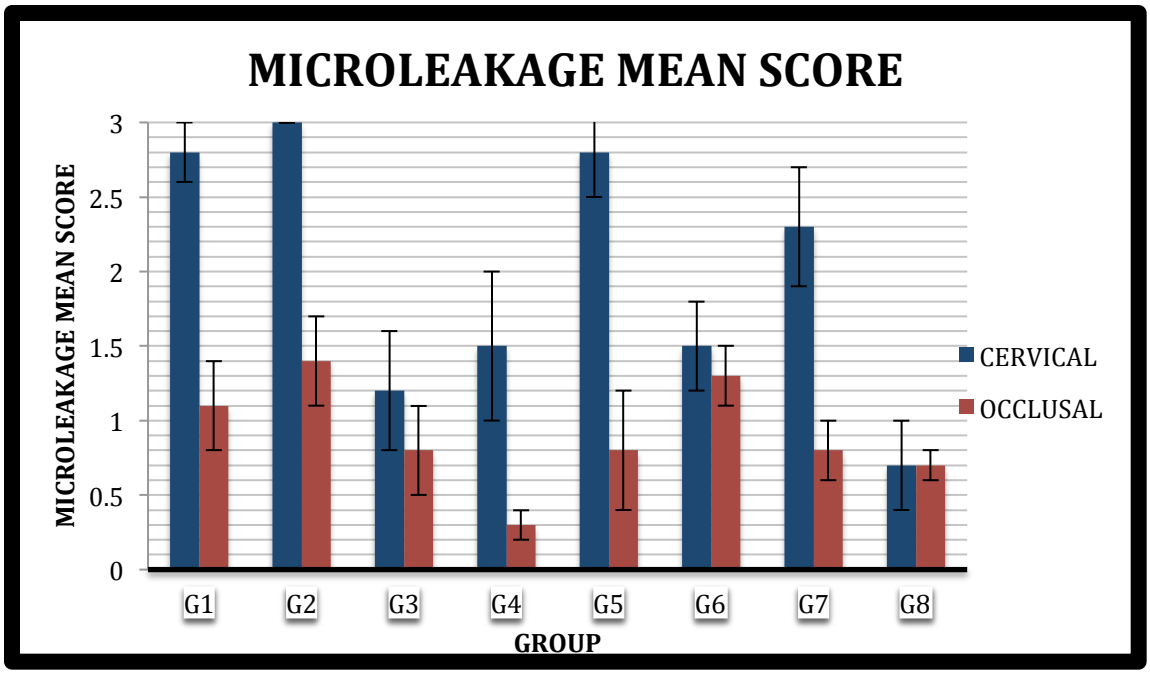
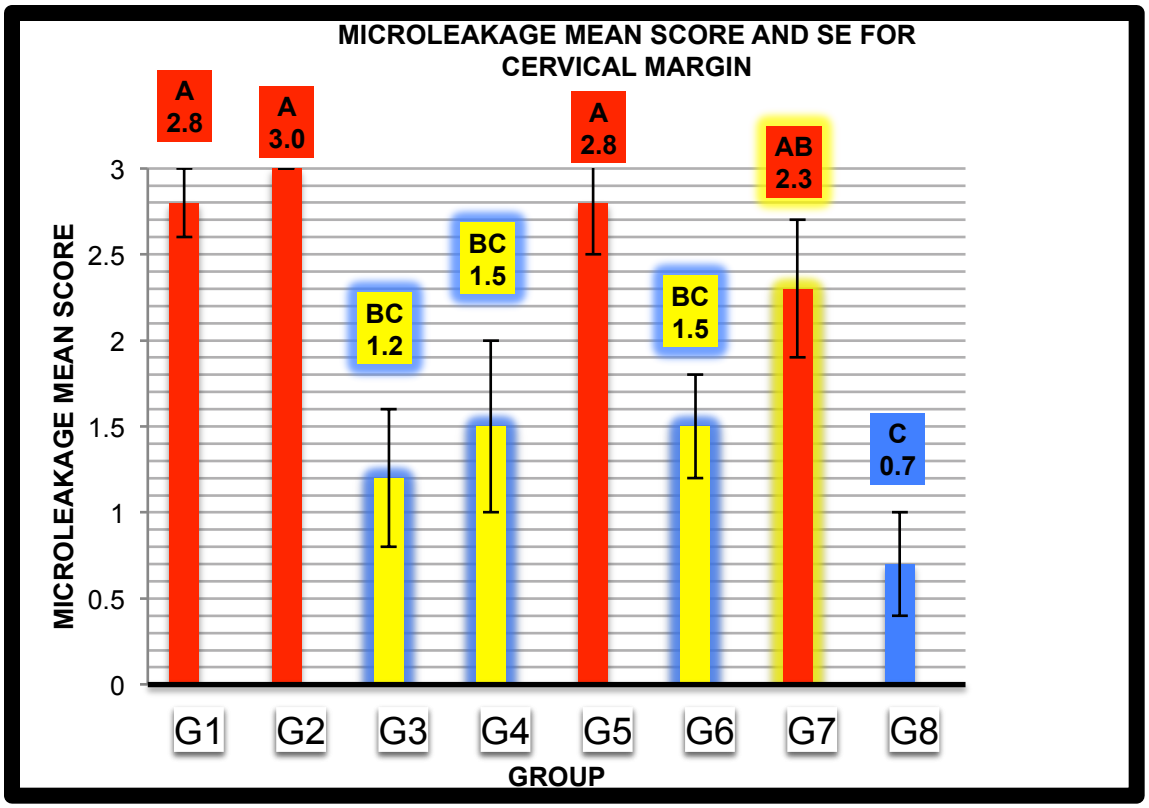


FIGURE 7. Score 3 methylene blue penetration.



GROUP	MATERIAL	PRETREATMENT	SURFACE	SD	SE
G1	Ketac Nano (3M)	Ketac Nano Primer	Cervical	0.6	0.2
			Occlusal	1.0	0.3
G2	Ketac Nano (3M)	Polyacrylic acid	Cervical	0	0
			Occlusal	1.0	0.3
G3	Photac Fil (3M)	Ketac Nano Primer	Cervical	1.4	0.4
			Occlusal	1.1	0.3
G4	Photac Fil (3M)	Polyacrylic acid	Cervical	1.6	0.5
			Occlusal	0.5	0.1
G5	Fuji Filling LC (GC America)	GC Self Conditioner	Cervical	0.9	0.3
			Occlusal	1.3	0.4
G6	Fuji Filling LC (GC America)	Polyacrylic acid	Cervical	1.0	0.3
			Occlusal	0.6	0.2
G7	Fuji II LC (GC America)	GC Self Conditioner	Cervical	1.2	0.4
			Occlusal	0.8	0.2
G8	Fuji II LC (GC America)	Polyacrylic acid	Cervical	0.9	0.3
			Occlusal	0.5	0.1

FIGURE 8. Microleakage mean score with standard error.



G1	Ketac Nano (3M)	Ketac Nano Primer
G2	Ketac Nano (3M)	Polyacrylic acid
G3	Photac Fil (3M)	Ketac Nano Primer
G4	Photac Fil (3M) **Control**	Polyacrylic acid
G5	Fuji Filling LC (GC America)	GC Self Conditioner
G6	Fuji Filling LC (GC America)	Polyacrylic acid
G7	Fuji II LC (GC America)	GC Self Conditioner
G8	Fuji II LC (GC America) **Control**	Polyacrylic acid

FIGURE 9. Significantly similar groups on cervical margin.

DISCUSSION

There is a continuous search for the restorative material and technique that will provide optimal adhesion to tooth structure to minimize microleakage as well as have excellent mechanical and physical properties. Different microleakage test methods have been used for years to predict the performance of restorative materials at the tooth-restoration interface. The present study utilized the dye penetration technique *in vitro* to study microleakage when placing new RMGIC and their recommended dentin pretreatments.

Previously available resin-modified glass ionomer cement provides acceptable sealing at the margins of restorations.[5,17] Evidence was needed to prove the superiority of the bond to tooth structure of these relatively new paste-paste glass ionomer systems when used in combination with novel no-rinse dentin conditioners. This study compared the degree of microleakage at the tooth-restoration interface using either a polyacrylic acid or a non-rinse conditioner prior to placing either traditional powder-liquid or paste-paste RMGIC restorations. This study showed that both group and location effects were significant. At the occlusal margin, all groups performed well and there was no significant difference in microleakage among the groups, although control Group 4 (Photac Fil with Ketac conditioner) and Group 8 (Fuji II LC with GC Cavity Conditioner) showed the least mean values among all groups. At the cervical margin, Group 8 (Fuji II LC with GC cavity conditioner) showed the least mean microleakage scores followed by Group 3 (Photac Fil with Ketac Nano Primer), Group 4 (Photac Fil with Ketac Conditioner) and Group 6 (Fuji Filling LC with GC Cavity Conditioner).

Thermocycling is the only method used *in vitro* to simulate thermal stress in the mouth.[75] [76] For maximum longevity of the restoration, the coefficients of thermal expansion of the restorative material and the tooth substrate should be the same.[77] Previous studies have shown that RMGIC and dentin has similar coefficients of thermal expansion, while composite and dentin differ significantly.[78,79] Polymerization shrinkage or differences in coefficient of thermal expansion stress the bond and can lead to increased microleakage.

Research shows that the smear layer on the cavity preparation can affect the bond between RMGIC and dentin. If the smear layer is not removed, it can act as a weak point leading to cohesive failure during polymerization shrinkage and episodes of thermal expansion and contraction.[80] Several researchers reported improved bond strength when the smear layer was removed using polyacrylic acid before the use of RMGIC.[81,82] However, the bond strength of resin modified glass ionomer cement has been reported to be lower than resin composite materials.[83,84] Some researchers believe that the bond strength of resin modified glass ionomer cement containing monomer like HEMA can be improved by using a dentin primer and bonding agent.[71] It is likely that the new non-rinse pretreatments and paste-paste RMGIC systems were introduced by 3M and GC America to enhance the bonding and physical properties of traditional RMGIC. The composition of these newer materials (Table II, III[a], III[b] attracted our attention, especially in terms of microleakage. These materials appeared to be relying on more of a resin bond rather than a chemical bond like conventional GIC. Our study showed that the conventional RMGIC still performs better or at least the same as these newer materials. Other researchers also used different kinds of all-in-one or self-conditioner bonding systems

with conventional RMGIC to see the effect of these materials on the tooth- restoration interface based on the concept discussed earlier. The most recent study was done by Sabine. Fuji II LC with dentin conditioner (GC Tokyo, Japan), Xeno III (Densply Detrey GmbH, Germany), iBond experimental (Heraeus Kulzer & Co, Germany) and Adper Prompt-L-Pop (3M ESPE AG, Germany) were tested. No significant differences were found in terms of microleakage between either techniques of RMGIC restorations.[52]

The present study focused on evaluating the microleakage of the newer RMGIC and their recommended dentin pretreatment by comparing them with clinically proven RMGIC with a polyacrylic acid dentin conditioner. No attempt was made to study the effects of tooth preparation, restoration placement, and finishing methods because all procedures were accomplished following manufacturer's instructions. Some observations were made regarding handling techniques and technical difficulties of the materials. Manipulation of all the materials was relatively easy except for Fuji Filling LC, which is a hand-mixed material. The concern was that hand mixing of the material might incorporate voids into the material, and care had to be exercised to ensure appropriate quantities of Paste A and Paste B dispensed prior to mixing. This is reported merely as an observation because there was no attempt to evaluate the effects of hand-mixing in this study. For the same material, placement of material with a spatula compared with a syringe could have affected the integrity of the restoration as well. Also, every effort was made to reproduce the clinical situation, e.g., using extracted human molars and thermocycling to mimic the hot and cold changes; however, *in vitro* studies cannot reproduce the human oral environment completely. *In vitro* studies can exaggerate bonding capabilities due to a well-controlled environment that could not be possible in

the clinical situation. Surface protection of glass ionomer and resin-modified glass ionomer during material setting and after placement is required to avoid desiccation and early solubility of the material. RMGICs used in this study were not protected with materials like varnish or glaze resin due to the possibility of their interference with microleakage testing procedures. Our study design required the sealing of all the surfaces of the teeth except 2 mm surrounding the restoration margins with nail varnish in order to prevent the penetration of methylene blue through other surfaces. The nail varnish was allowed to dry for 20 minutes under dry conditions for adequate setting of the material and this may have increased the microleakage. However, this was done for all the samples in the study so that the effect of this drying should have been uniform on all these samples. In our study, restorative materials were placed in class V cavities prepared using a carbide bur on extracted caries-free molars. However, clinically, most class V restorations are placed due to decay or noncarious lesions. Therefore, enamel/dentin substrate characteristics in these situations may be different from the bonding substrates encountered in this *in vitro* study. Newer no-rinse conditioner with the paste-paste systems did not perform as well as polyacrylic acid with traditional RMGIC materials most likely due to following reasons:

- The modification of the smear layer with newer no-rinse conditioner might have worked as a weak link that can fail either cohesively or adhesively as discussed previously and lead to more microleakage compared with polyacrylic acid that completely removes the smear layer.
- Increased polymerization shrinkage or difference in coefficient of thermal expansion may also lead to increased microleakage.

Incorporation of more resin in RMGIC can improve the mechanical properties, physical properties, and bond strength, but this can also lead to more microleakage due to increases in polymerization shrinkage or differences in the coefficient of thermal expansion. Further research is needed to study the effects of these new conditioners on tooth substrate and a new type of paste-paste glass ionomer cements. These new conditioners and the kind of bonding achieved with these materials play a crucial part in predicting the longevity of the restoration. More clinical studies are needed to evaluate the clinical short- and long-term outcomes of newer restorative materials.

SUMMARY AND CONCLUSIONS

The purpose of this study was to evaluate the microleakage of two new paste-paste RMGIC systems and their respective no-rinse pretreatments and compare them with the control groups of conventional RMGIC using polyacrylic acid conditioners. Class V artificial preparations were prepared in all the teeth followed by restoration as shown in Table I. We used 2.0-percent methylene blue, an organic dye, for microleakage measurement. Sections were scored as shown in Figure 4.

It was found that on the occlusal interface there was no significant difference among groups, while on the cervical interface there was a significant difference among groups. Occlusal interfaces performed better compared with cervical interfaces in all groups except Group 8, where both cervical and occlusal interfaces performed the same. Fuji II LC with GC Cavity Conditioner performed the best on the cervical interface. Overall, on both occlusal and cervical interfaces, the control groups Fuji II LC (GC Self-Conditioner) and Photac Fil (Ketac cavity conditioner) performed well compared with newer materials. Based on our results we can conclude that:

- Cervical margins show more microleakage compared with occlusal margins.
- Use of polyacrylic acid with Photac Fil and Fuji II LC is still superior compared with the use of newer no-rinse conditioners with these materials.

- Newer no-rinse conditioners with the new paste-paste systems did not perform as well in most situations compared with traditional RMGIC materials with polyacrylic acid.
- The newer no-rinse conditioners did not necessarily decrease microleakage when used with traditional RMGIC such as Photac Fil and Fuji II LC.
- Complete removal of the smear layer performed better than the modification of the smear layer before restoration of the tooth with RMGIC.

In summary, within the limitations of the present study, the findings suggest that the use of new no-rinse pretreatment systems did not necessarily improve the marginal sealing when compared with conventional polyacrylic acid. In most cases, traditional RMGIC material with polyacrylic acid performed better than the newer materials. Newer paste-paste RMGIC did not perform well when used in conjunction with polyacrylic acid conditioning.

REFERENCES

1. McCabe JF. Resin-modified glass-ionomers. Biomaterials 1998;19(6):521-7.

2. Wilson AD, Kent BE. A new translucent cement for dentistry. The glass ionomer cement. Br Dent J 1972;132-5.

3. Franco EB, Benetti AR, Ishikiriama SK. 5-year clinical performance of resin composite versus resin modified glass ionomer restorative system in non-carious cervical lesions. Oper Dent 2006;31(4):403-8.

4. Loguercio AD, Reis A, Barbosa AN, Roulet JF. Five-year double-blind randomized clinical evaluation of a resin-modified glass ionomer and a polyacid-modified resin in noncarious cervical lesions. J Adhes Dent 2003;5(4):323-32.

5. Sidhu SK. Clinical evaluations of resin-modified glass-ionomer restorations. Dent Mater 2010;26(1):7-12

6. Barry TI, Clinton DJ, Wilson AD. The structure of a glass-ionomer cement and its relationship to the setting process. J Dent Res 1979;58:1072-79.

7. Berg JH, Donly KJ, Posnick WR. Glass ionomer-silver restorations: a demineralization-remineralization concept. Quintessence Int 1988;19(9):639-41.

8. Mathis RS, Ferracane JL. Properties of a glass-ionomer/resin-composite hybrid material. Dent Mater 1989;5(5):355-8.

9. 3M USA World wide web http://mws9.3m.com/mws/mediawebserver.dyn?6666660Zjcf6lVs6EVs66S3LpCOrrrrQ 2011

10. GC AMERICA USA World wide web www.gcamerica.com/products/operatory/gc_fuji_filling_LC/index.php Page 1 2011

11. 3M USA World wide web http://multimedia.3m.com/mws/mediawebserver?mwsId=66666UuZjcFSLXTtnxTclxMEEVuQEcuZgVs6EVs6E666666--&fn=ketac_nano_tds.pdf 2011

12. GC AMERICA USA World wide web http://www.gcamerica.com/products/operatory/GC_Fuji_Filling_LC/FujiFillingLC_IFU.pdf 2011

13. 3M USA World wide web http://www.rvdalab.com/pdf/KetacNanoLight.pdf 2011

14. Davidson CL, Feilzer AJ. Polymerization shrinkage and polymerization shrinkage stress in polymer-based restoratives. J Dent 1997;25(6):435-40.

15. Dietrich T, Lösche AC, Lösche GM, Roulet JF. Marginal adaptation of direct composite and sandwich restorations in Class II cavities with cervical margins in dentine. J Dentistry 1999;27(2):119-28.

16. Marthaler TM. Changes in dental caries 1953-2003. Caries Res 2004;38(3):173-81.

17. Nikolaos K, Vassilili T, Christine T, Eirini T. The early fluoride release pattern of an aged glass ionomer treated with fluoride. EJPRD 2007;15:135-41

18. Davidovich E, Weiss E, Fuks AB, Beyth N. Surface antimicrobial properties of glass ionomer cements used in atraumatic restorative treatment. J Am Dent Assoc 2007; 138:1347-52.

19. Mount, GJ. Minimal intervention dentistry: rationale of cavity design. Oper Dent 2003;28:92-9.

20. Noack, MJ, Wicht, Haak R. Lesion orientated caries treatment – a classification of carious dentin treatment procedures. Oral Health Prev Dent 2004;2:301-6.

21. Kotsanos N. An intraoral study of caries induced on enamel in contact with fluoride-releasing restorative materials. Caries Res 2001;35:200-4.

22. Wiegand A, Buchalla W, Attin T. Review on fluoride-releasing restorative materials. Fluoride release and uptake characteristics, antibacterial activity and influence on caries formation. Dent Mater 2007;23(3):343-62.

23. Berg JH, Donly KJ, Posnick WR. Glass ionomer-silver restorations: a demineralization-remineralization concept. Quintessence Int 1988;19(9):639-41.

24. Tam LE, McComb D, Pulver F. Physical properties of proprietary light-cured lining materials. Oper Dent 1991;16:210-7.

25. Dunne SM, Goolnik JS, Millar BJ, Seddon RP. Caries inhibition by a resin-modified and conventional glass ionomer cement in vitro. J Dent 1996;24:91-4.

26. Abdalla AI, Alhadainy HA, Garcia-Godoy F. Clinical evaluation of glass ionomers and compomers in Class V carious lesions. Am J Dent 1997;10:18-20.

27. Sharanbir K. Sidhu S. Clinical evaluations of resin-modified glass-ionomer restorations dental materials Dent Mater 2010;26:7-12

28. Tyas MJ, Burrow MF. Adhesive restorative materials: a review. Aust Dent J 2004; 49:112-21.

29. De Munck J, Van Landuyt K, Peumans M, et al. A critical review of the durability of adhesion to tooth tissue: methods and results. J Dent Res 2005;84:118-32.

30. Mongkolnam P, Tyas MJ. Light-cured lining materials: a laboratory study. Dent Mater 1994;10:196-202.

31. Hotta M, Aono M. Adaptation to the cavity floor of the light cured glass ionomer cement base under a composite restoration. J Oral Rehabil 1994;21:679-85.

32. Pachuta SM, Meiers JC. Dentin surface treatments and glassionomer microleakage. Am J Dent 1995;8:187-90.

33. Friedl KH, Powers JM, Hiller KA. Influence of different factors on bond strength of hybrid ionomers. Oper Dent 1995;20:74-80.

34. Lin A, McIntyre NS, Davidson RD. Studies on the adhesion of glass-ionomer cements to dentin. J Dent Res 1992;71:1836-41.

35. Yiua CKY, Taya FR, Kinga NM, Pashley DH, Carvalho RM, Carrilho D. Interaction of resin-modified glass-ionomer cements with moist dentine. J Dent 2004; 32: 521-30.

36. Gladys S, Van Meerbeek B, Lambrechts P, Vanherle G. Marginal adaptation and retention of a glass-ionomer, resin-modified glass-ionomers and a polyacid-modified resin composite in cervical Class-V lesions. Dent Mater 1998;14:294-306.

37. Folwaczny M, Loher C, Mehl A, Kunzelmann KH, Hickel R. Class V lesions restored with four different tooth-colored materials – 3-year results. Clin Oral Invest 2001;5:31-9.

38. Loguercio AD, Reis A, Barbosa AN, Roulet JF. Five-year double-blind randomized clinical evaluation of a resin-modified glass ionomer and a polyacid-modified resin in noncarious cervical lesions. J Adhes Dent 2003;5:323-32

39. Neo J, Chew CL, Yap A, Sidhu S. Clinical evaluation of tooth-colored materials in cervical lesions. Am J Dent 1996;9:15-8.

40. Friedl KH, Powers JM, Hiller KA. Influence of different factors on bond strength of hybrid ionomers. Oper Dent 1995;20(2):74-80.

41. Geerts S, Seidel A, Albert I, Gueders A. Microleakage after thermocycling of three self-etch adhesives under resin-modified glass-ionomer cement restorations. Int J Dent 2010;2010:728453.

42. Sidhu SK, Schmalz G. The biocompatibility of glass-ionomer cement materials. A status report for the American Journal of Dentistry. Am J Dent 2001;14:387-6.

43. Stanley HR. Local and systemic responses to dental composites and glass ionomers. Adv Dent Res 1992;6:55-64.

44. van Dijken JW, Kieri C, Carlén M. Longevity of extensive class II open-sandwich restorations with a resin-modified glass-ionomer cement. J Dent Res 1999;78:1319-25.

45. van Dijken JW. Longevity of new hybrid restorative materials in class III cavities. Eur J Oral Sci 1999;107:215-9.

46. Nicholson JW, Czarnecka B. The biocompatibility of resin-modified glass-ionomer cements for dentistry. Dent Mater 2008;24:1702-8.

47. Croll TP, Bar-Zion Y, Segura A, Donly KJ. Clinical performance of resin-modified glass ionomer cement restorations in primary teeth: a retrospective evaluation. J Am Dent Assoc 2001;132(8):1110-6.

48. Mitra SB. Adhesion to dentin and physical properties of a light-cured glass-ionomer liner/base. J Dent Res 1991;70(1):72–4.

49. Wilson AD. Resin-modified glass-ionomer cements. Int J Prosthodont 1990;3(5):425-9.

50. Hickel W, Dasch R, Janda M, Tyas M, Anusavice K, New direct restorative materials. FDI Commission Project. Int Dent J 1998:48:3-16.

51. Tyas MJ, Burrow MF. Adhesive restorative materials: a review. Aust Dent J 2004;49:112-21.

52. van Dijken JWV, Pallesen U. Fracture frequency and longevity of fractured resin composite, polyacid-modified resin composite, and resin-modified glass ionomer cement class IV restorations: an up to 14 years of follow-up. Clin Oral Invest 2010;14(2):217-22.

53. Fritz UB, Finger WJ, Uno S. Resin-modified glass ionomer cements: bonding to enamel and dentin. Dent Mater 1996;12(3):161-6.

54. Fritz UB, Finger WJ, Uno S. Resin-modified glass ionomer cements: bonding to enamel and dentin. Dent Mater 1996;12(3):161-6.

55. Gladys S, Van Meerbeek B, Braem M, Lambrechts P, Vanherle G. [Characterization of glass ionomer cements containing resin]. Rev Belge Med Dent 1996;51:36-53.

56. Going RE. Think micro leakage for better prevention. Dent Surv 1972; 48:42-3.

57. Ben-Amar A. Reduction of microleakage around new amalgam restoration. J Am Dent Assoc 1989;119:725-8

58. Trowbridge M. Model systems for detetmining biologic effects of micro leakage. Oper Dent 1987;12:164-72.

59. Crisp S, Wilson AO. Radioactive tracer technique for monitoring of micro leakage: an interim report. J Biomed Mater Res 1980;14:373-82.

60. Crim GA. Assessment of microleakage of three dentinal bonding systems. Quintessence Int 1990;21:295-7.

61. Fayyad MA, Ball PC. Cavity sealing ability of lathe-cut, blend and spherical amalgam alloys: a laboratory study. Oper Dent 1984;9:86-93.

62. Shortall AC. Microleakage, marginal adaptation and composite resin restorations. Br Dent J 1982;153:223-7.

63. El Halim S, Zaki D. Comperative evaluation of microleakage among three different glass ionomer types. Oper Dent 2011,36:1,36-42.

64. Katleen IM. Delmé P, Deman M, De Bruyne A, Roeland J, De Moor G. Microleakage of four different restorative glass ionomer formulations in Class V cavities: Er:YAG laser versus conventional preparation. Photomed Laser Surg 2008;26(6):541-9.

65. Elledge DA. Multifunctional bases and liners. Dent Clin North Am 1998;42(4):739-54.

66. Vilkinis V, Hörsted-Bindslev P, Baelum V. Two-year evaluation of class II resin-modified glass ionomer cement/composite open sandwich and composite restorations. Clin Oral Invest 2000;4(3):133-9.

67. Nakanuma K, Hayakawa T, Tomita T, Yamazaki M. Effect of the application of dentin primers and a dentin bonding agent on the adhesion between the resin-modified glass-ionomer cement and dentin. Dent Mater 1998;14(4):281-6.

68. Pereira PNR, Yamada T, Inokoshi S, Burrow MF, Sano H, Tagami J. Adhesion of resin-modified glass ionomer cements using resin bonding systems. J Dent 1998;26(5-6):479-85.

69. Gallo JR, Comeaux R, Haines B, Xu X, Burgess JO. Shear bond strength of four filled dentin bonding systems. Oper Dent 2001;26(1):44-7.

70. Schittly E, Besnault C, Bouter D, Ruse ND, Degrange M, Attal JP. Influence of self-etching primer preapplication on the dentin-titanium shear bond strength mediated by a resin-modified glass-ionomer cement. Int J Prosthodont 2005;18(2):112–6.

71. Mali P, Despande S, Singh A. Microleakage of restorative materials: An in vitro study. J Indian Soc Pedodont Preventive Dent 2006;24(1):15-8.

72. 3M USA World wide web http://multimedia.3m.com/mws/mediawebserver?mwsId=66666UuZjcFSLXTt4Xf6mXTtEVuQEcuZgVs6EVs6E666666--&fn=photac_fil_q_apl_ifu_we.pdf. 2011

73. Delmé KI, Deman PJ, De Bruyne MA, De Moor RJ. Microleakage of four different restorative glass ionomer formulations in class V cavities: Er:YAG laser versus conventional preparation. Photomed Laser Surg 2008 Dec;26(6):541-9.

74. 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(4):303-7.

75. Ferrari M, Garcia-Godoy F. Sealing ability of new generation adhesive-restorative materials placed on vital teeth. Am J Dent 2002;15(2):117-28.

76. Barnes DM, Thompson VP, Blank LW, McDonald NJ. Microleakage of class 5 composite resin restorations: a comparison between in vivo and in vitro. Oper Dent 1993;18(6):237-45.

77. Chuang SF, Liu JK, Chao CC, Liao FP, Chen YHM. Effects of flowable composite lining and operator experience on microleakage and internal voids in class II composite restorations. J Prosthet Dent 2001;85(2):177-83.

78. Naasan MA, Watson TF. Conventional glass ionomers as posterior restorations: a status report for the American Journal of Dentistry. Am J Dent 1998;11(1):36-45.

79. Dietrich T, Lösche AC, Lösche GM, Roulet JF. Marginal adaptation of direct composite and sandwich restorations in Class II cavities with cervical margins in dentine. J Dent 1999;27(2):119-28.

80. Tao L, Pashley DH. Shear bond strengths to dentin: effects of surface treatments, depth and position. Dent Mater 1988;4(6):371-8.

81. Carvalho RM, Yoshiyama M, Horner JA, Pashley DH. Bonding mechanism of variglass to dentin. Am J Dent 1995;8(5):253-8.

82. Triana R, Prado C, Garro J, Garcia-Godoy F. Dentin bond strength of fluoride-releasing materials. Am J Dent 1994;7(5):252-4.

83. Prati G, Montanari G, Biagini F, Pashley DH, Effects of dentin surface treatments on the shear bond strength of Vitrabond. Dent Mater 1992;8:21-6.

84. Irae M, Nakai M. Marginal gap of recent light-activated restorative glass ionomers immediately after light activation -- effect of setting shrinkage and shear bond strength. J Jpn Dent Mater 1993:12:790-4.

ABSTRACT

MICROLEAKAGE IN NEW RESIN-MODIFIED GLASS IONOMER CEMENTS USING NEW NO RINSE CONDITIONERS: AN *IN-VITRO* STUDY

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Since their introduction in 1970, glass ionomer cements have been used in a wide variety of clinical situations in dentistry. The main advantages of glass ionomer cements are chemical bonding, fluoride release and uptake, excellent seal against microleakage, and biocompatibility. The main objective of this study was to compare the microleakage of two new paste-paste glass ionomer systems to their traditional RMGIC counterparts when conditioning the dentin with newly developed no-rinse conditioners or polyacrylic acid. Materials and methods: Standardized cavity preparations were made, centered on the cementoenamel junction of the buccal surface, on 96 extracted human molars divided in 8 groups (n = 12). G1 Ketac Nano with Ketac Nano Primer, G2 Ketac Nano with Ketac Conditioner, G3 Photac Fil with Ketac Nano Primer, G4 Photac Fil with Ketac Cavity Conditioner, G5 Fuji Filling LC with GC Self Conditioner, G6 Fuji Filling LC with GC Cavity Conditioner, G7 Fuji II LC with GC Self Conditioner, G8 Fuji II LC

with GC Cavity Conditioner. The cavities were treated with either a no-rinse or polyacrylic acid conditioner and restored with a paste-paste RMGIC or traditional RMGIC from the same manufacturer (n =12). The teeth were then sealed to within 2 mm of the restoration margins and thermocycled. The teeth were immersed in 2.0-percent methylene blue and stored at room temperature for 24 hours. Then, the teeth were be embedded in resin and sectioned longitudinally in a buccolingual direction making 1 section (1 mm thick) per tooth. The occlusal and gingival restoration margins of each specimen were examined with a stereomicroscope at X10 magnification to determine the degree of microleakage. Results: Mixed-model ANOVA was used to test the fixed effect of the eight groups and cervical vs. occlusal location within each tooth sample on microleakage, with sample as the random effect. Both main effects and the interaction are significant, $p < 0001$ for both group and location effects, and $p = 0.0013$ for the interaction of group and location. The cervical interface showed more microleakage in all groups except group 8 where microleakage was the same as at the occlusal margin. No significant difference was observed among groups for microleakage at the occlusal interface. There was significant difference among groups at the cervical interface with Fuji II LC using GC Cavity Conditioner performing best. For the occlusal interface Group 4 performed the best and Group 2 performed the worst, although the difference was not significant among the groups. For the cervical interface, Group 8 performed the best followed by Group 3, Group 4 and Group 6, although these four groups were not significantly different. For the cervical interface, group 2 performed the worst followed by group 1. Based on these results we can conclude that, overall, traditional RMGIC with

polyacrylic acid conditioning performed better than the new paste-paste RMGIC systems utilizing the no-rinse conditioners.

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August 2009 to August 2011	Certificate in Operative Dentistry Indiana University School of Dentistry. Indianapolis, IN Major: Operative Dentistry Minor: Dental Materials, Preventive Dentistry
August 2010 to August 2011	Simulation Lab instructor Indiana University School of Dentistry
August 2011 to present	Accelerated DDS program University of Detroit Mercy School of Dentistry
August 2011 to present	Clinic and Simulation Lab Instructor University of Detroit Mercy School of Dentistry, Part-time Adjunct Faculty.

Professional Organizations

American Academy of Operative Dentistry
Indian Dental Association, India
Gujarat Dental Council, Gujarat, India