Effect of Salivary Contamination on Marginal Adaptation of Different Types of Glass Ionomer Cements Restorations

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Abstract Aim: To study the effect of salivary contamination on the marginal adaptation of class V cavities restored with three different types of glass ionomer cements. **Materials and methods**: Forty five, caries-free, freshly extracted human sound molars from middle aged patients were collected from surgery clinic of Tanta University. The teeth were examined by trans-illumination to exclude those exhibiting enamel fractures or cracks. A class V cavity preparation was done on the buccal or lingual surface of each tooth with cylindrical diamond bur under air-water cooling. The prepared teeth were randomly divided into nine groups (5 teeth each) corresponding to different glass ionomer materials and saliva contamination timing. **Results**: SEM examination revealed that no marginal gaps were detected at the enamel-GIC interface in the different tested groups that were not subjected to salivary contamination. While in the samples that were subjected to salivary contamination there were marginal gaps formation. **Conclusion**: Salivary contamination reduced marginal adaptation of different glass ionomer restorative materials. Nano-Ionomer showed least marginal gaps and better marginal adaptability when compared to CGIC and RMGIC.

1. Introduction

The success of any restorative material is indicated by its longevity in the oral cavity which is affected by the quality of the bonded interface between the restorative material and the tooth structure. (1) Good marginal sealing decreases microleakage considerably, reduces the postoperative sensitivity, the occurrence of secondary caries and improves the longevity of the fillings. By contrast, the presence of leaked enamel margin may increase the risk of in growth of microorganisms resulting in caries development (2). An important factor in obtaining good marginal adaptation is adhesion to the hard dental tissues. (3) Glass ionomer cements have proper chemical adhesion to tooth structure, fluoride release, biocompatibility, lower shrinkage values, reduced microleakage and acceptable esthetics. They are largely used today in a variety of clinical situations as restoratives, linings, luting and sealing materials. (4,5) Marginal adaptation defects and dimensional changes lead to marginal leakage. The slower setting of conventional glass ionomer cement are thought to permit stress relief within the restoration while the resin-modified glass ionomer exhibit more rapid setting contraction through the polymerization of the polymer component. When the RMGIC is extended to enamel margins, there may be considerable risk of enamel fracture. (6) However, this is not necessarily borne out by research as the RMGICs appear to display substantially better adaptation to dentine than the conventional materials. It is possible that a propensity for water absorption by the hydroxyl-ethyl methacrylate (HEMA) content compensates for the initial setting contraction in the RMGICs. (7) Studies on the effect of saliva contamination on the quality of the bond of glass ionomer restorations reported range of effects. It may has no effect on enamel and dentin bond strength (8) to some effect on marginal integrity (9) to substantial bond strength reduction that cannot be recovered with etching or rinsing. (1O)

2. Materials and Methods

Forty five, caries-free, freshly extracted human sound molars from middle aged patients were collected from surgery clinic of Tanta University. The teeth were examined by transillumination to exclude those exhibiting enamel fractures or cracks. They were cleaned from tissue remnants and debris using periodontal scalers and curettes followed by polishing with slurry of pumice and rubber prophylaxis cup then water washed properly and dried. (1)

The teeth were stored in normal saline solution not more than three months at room temperature and saline was daily changed to prevent any dehydration. (11)

A class V cavity preparation was done on the buccal or lingual surface of each tooth with cylindrical diamond bur (Mani inc.8-3 Kiyohara Industrial Park,

Tochigi 321-3231, Japan) under air-water cooling. The bur was replaced after every 4 preparations. (11) The dimensions of the cavity were 3-mm in width (mesio _distaly), 2-mm in depth and 3-mm in length (occluso_cervical) with the occlusal margin in_enamel and the gingival margin located in cementum 1.0 mm below cemento-enamel junction using a graduated periodontal probe. (12)

Unstimulated human saliva collected from one healthy individual on the day of the test in the afternoon. This saliva was collected immediately prior to conditioning, ensuring that two hours had elapsed since the volunteer had brushed his or her teeth, eaten or drank liquids. (8)

The prepared teeth were randomly divided into nine groups (5 teeth each) corresponding to different glass ionomer materials and saliva contamination timing:

Groups 1, 2, 3: restored with conventional glass ionomer cements (GC- Fuji IX GP).

Groups 4, 5, 6: restored with resin modified glass ionomer cements (GC- Fuji VIII GP) .

Groups 7, 8, 9: restored with nano filled resin modified glass ionomer cements (Ketac TM Nano).

Groups 1,4,7: control groups.

Groups 2,5: the cavities were contaminated with saliva before the conditioner application.

Groups 3,6: the cavities were contaminated with saliva after the conditioner application.

Group 8: the cavities were contaminated with saliva before the primer application.

Group 9: the cavities were contaminated with saliva after the primer application.

Table 1: The nine groups and the followed steps for each one of the three types of glass ionomer cements used in this study.

G	Saliva	Acidic Primer	Restorative Material
1	--	GC Dentin Conditioner	GC Fuji IX GP
2	Before Conditioner	GC Dentin Conditioner	GC Fuji IX GP
3	After Conditioner	GC Dentin Conditioner	GC Fuji IX GP
4	--	GC Dentin Conditioner	GC Fuji VIII GP
5	Before Conditioner	GC Dentin Conditioner	GC Fuji VIII GP
6	After Conditioner	GC Dentin Conditioner	GC Fuji VIII GP
7	--	Ketac™ Nano Primer	Ketac™ Nano
8	Before primer	Ketac™ Nano Primer	Ketac™ Nano
9	After primer	Ketac™ Nano Primer	Ketac™ Nano

Samples in each group were thermo-cycled in a thermo-cycling apparatus (Julabo Thermocycler Micatronics apparatus, JULABO GmbH, Gerhard Juchheim-Strasse 1 / Germany) consisting of 1000 cycles simulating about 2 years of clinical service, alternating between 5oc-55oc with 30 seconds immersion time and 30 seconds transfer time. (13)

Samples were processed for SEM (QUANTA FEG250 scanning microscope, FEI 5350 NE Dawson Creek Drive Hillsboro, Oregon 97124 USA) evaluation to examine the restoration margins at (60x and 120x) magnification. The degree of marginal gap was determined as the ratio of gap length to the total marginal length and converted to a percentage. The marginal gap was measured for all the samples using AutoCAD software. (14) Figure 2.

3. Results

Scanning electron microscope (SEM) examination shows various lengths of open margins from the total margin length for class V restored with the three different types of glass ionomer restorative materials.

This examination revealed no detected marginal gaps at the enamel-GIC interface in the different tested groups not subjected to salivary contamination figures (2-B), (2-D). It also revealed small marginal gaps at the cementum-GIC interface in the different tested groups not subjected to salivary contamination figures (2-A), (2-C).

While in the samples that were subjected to salivary contamination there were marginal gaps formation. Gaps show higher scores when contamination occurred after primer applications (figure 2-F) than when contamination occurred before primer application (figure 2-E).

SEM photographs of the tested samples were used for gap length measurement using AutoCAD software. This was determined as the ratio of the length of gaps to the total length of the margins, and then converted to a percentage. So, the length of marginal gap formed was calculated as a percentage of the entire margin length. The recorded data related to

each group were collected, tabulated and statistically analyzed.

Numerical variables were expressed using descriptive statistics as mean, standard deviation, standard error for mean and rang. Analysis of variance (one way ANOVA) used to compare materials in each variable. P-value <0.05 was considered as significant difference. Statistical analyses were performed using Statistical Package for Social Sciences (SPSS version 23,

IBM Corp. 2011. USA, Armonk, NY).

It was found that, the highest mean value of open margin was recorded for group 3 restored with GC Fuji IX after salivary contamination recoding 8.65 mm ± 0.391, while the lowest mean marginal gap length value was found at group 7 restored with Ketac Nano without salivary contamination recording 0.894 mm ± 0.259 as shown in Figure 1. ANOVA one-way test was used to compare the tested groups at level of significant p<0.05 and reported a high statistical

significant difference at p value 0.000 (indicate that there is highly significant difference at (p<0.001). as shown in Table (2).
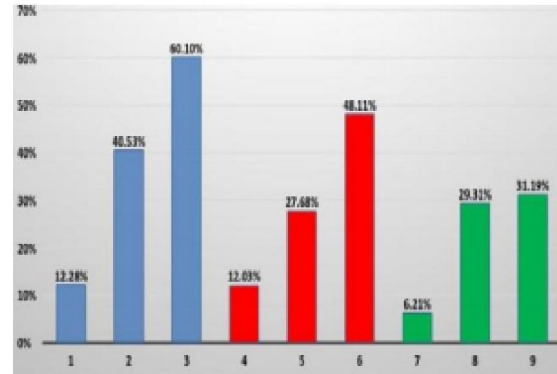

Fig (1): Bar chart representing the percentage of marginal gap of all tested groups.

Table 2: Statistical analysis, mean and standard deviation of the mean marginal gap length values of all groups.

| Materials	Groups	Mean ± S.D	S.E	Range	F	p-value
High viscous conventional glass ionomer	**Group1**	1.77 ± 0.201	0.089	1.59-2.05		
	Group2	5.84 ± 0.669	0.299	4.90-6.53	280.566	0.000**
	Group3	8.65 ± 0.391	0.175	8.07-9.03		
RMGI resin modified glass ionomer	**Group4**	1.73 ± 0.242	0.109	1.48-2.00		
	Group5	3.98 ± 0.509	0.509	3.42-4.80	104.875	0.000**
	Group6	6.93 ± 0.808	0.808	6.06-7.90		
Ketac N100-Nano filled RMGI	**Group7**	0.894 ± 0.259	0.116	0.520-1.20		
	Group8	4.22 ± 1.15	0.515	2.75-5.70	26.191	0.000**
	Group9	4.49 ± 0.952	0.426	3.53-5.90		
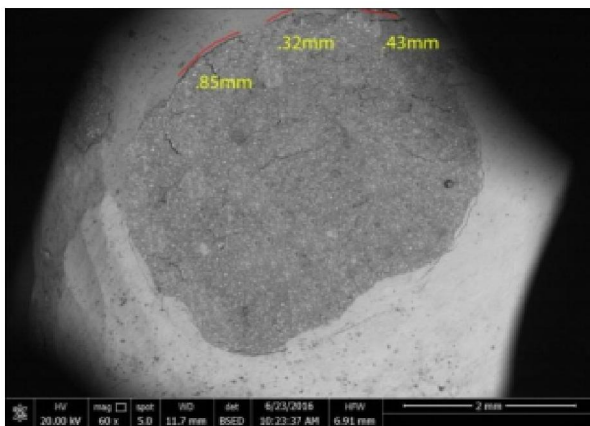
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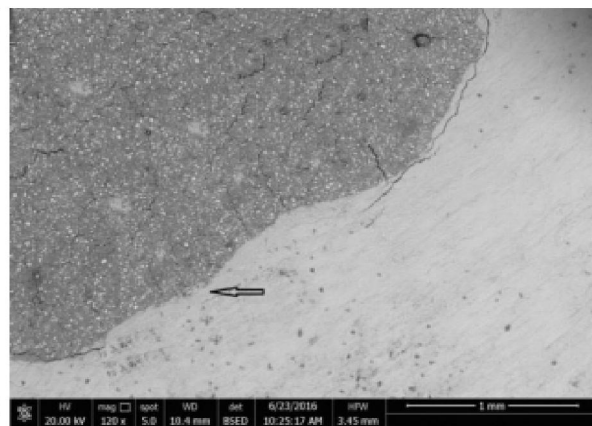
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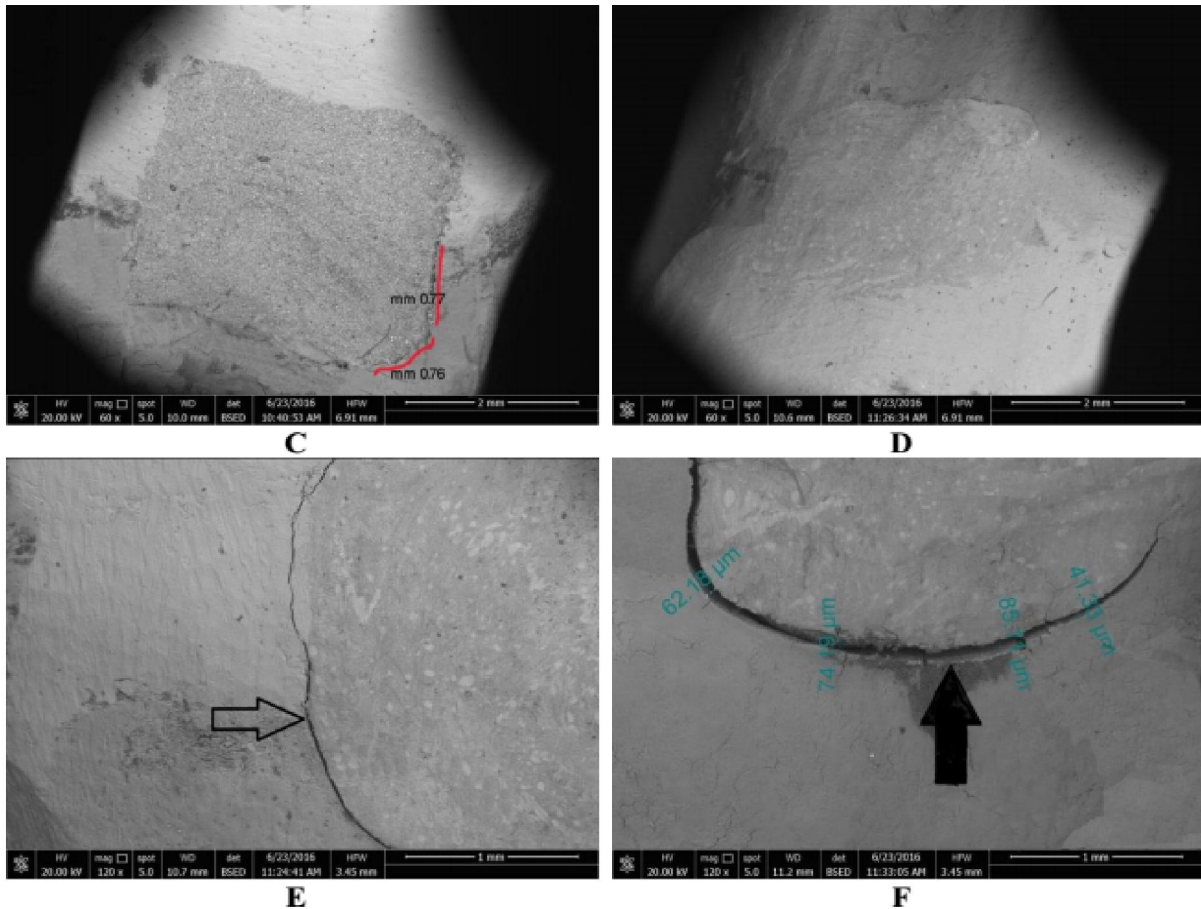
Fig (2): Some representative samples of scanning electron micrographs. (A) displaying the whole parameter of GC Fuji IX GP in group 1 with no marginal gap formation at enamel margin and small gap formation at cementum margin (Mag. X60). The higher magnification (x120) in (B) showing the interface with no gap formation "arrow" at enamel margin. (C) Displaying the whole parameter of GC Fuji VIII GP in group 4 with no marginal gap formation at enamel margin and small gap formation at cementum margin (Mag. X60). (D) Showing Ketac Nano in group 7 with no marginal gap formation (Mag. X60). (E, F) Showing Ketac Nano in group 8, 9 respectively with marginal gap formation (Mag. X120).

4. Discussion

This in vitro study was performed to study the effect of salivary contamination either before or after the acidic conditioner or primer application on the marginal adaptation of class V cavities restored with three different types of glass ionomer cements.

In the present study Class V cavities were prepared with margins partly in enamel and partly in cementum which presenting challenging scenario for the restorative material, as the large bonding area (high C-factor) allows greater stress development at the adhesive interface. (15).

Thermocycling has been used to simulate oral conditions, which is widely used in dental research.

The number of cycles used in this study (1000 cycles) representing 2 years in clinical service which is in accordance with the number of cycles mentioned in previous studies. (1)

Scanning Electron Microscope (SEM) was used to measure the marginal gap as it provides high-resolution transmission electron micrographs, elemental maps of the same specific area can be analyzed and it also provides a more accurate picture of the marginal leakage. (14,16)

SEM evaluation followed by the marginal gap measurement using AutoCAD software allows a quantitative and qualitative evaluation of the interface of the restoration biomaterials and the tooth

biostructure as influenced by the restoring materials. (17) The coefficient of thermal expansion of GC Fuji IX GP is similar to that of adjacent tooth structure, which could be a reason for good marginal adaptation observed in group 1 without saliva contamination as shown in figure (2-A).

In the current study nano-filled RMGI showed more marginal adaptation than CGIC and RMGIC at gingival margins. This may be due to the higher filler loading in the nano-filled type that may result in lower polymerization shrinkage and lower coefficient of thermal expansion, thus improving the long-term bonding to tooth structure. (13,18) as shown in figure (1).

Bond interface of Ketac Nano specimens showed an indistinct interface between the margin of the tooth structure and the restoration. Nano-filled resin-modified glass ionomer showed similar appearance with dentin, and it was difficult to distinguish between the material and tooth structure fig (2-D). This may be due to its nanostructure and micromechanical bonding at the interface between the material and tooth structure. (18)

In contrast to this study, some investigations showed that the nanoionomer demonstrated more marginal adaptation compared to conventional glass-ionomer cement. (19,20,21) In the nano-filled type of glass ionomer, lower polymerization shrinkage may be expected since higher filler loading is found. (19) On the other hand, Coutinho (22) reported that nanoionomers exhibited a superficial dentin and enamel interaction. Thus, micro mechanical interlocking was found inadequate. Abd El Halim (19) compared the microleakage of three glass ionomers in vitro and found that leakage occurs with all types of glass ionomer with an increase in immersion time. They reported that nano-filled RMGI showed the lowest microleakage scores followed by the other resin-modified glass ionomers. (18)

In contrary to the present findings, other investigations showed that nano-filled RMGI is not more advantageous than high viscosity glass ionomers from the perspective of effective marginal sealing in class V cavities. This may be explained by the resin content increasing the polymerization shrinkage. This finding is in agreement with some other studies demonstrating that GIC undergoes minimal setting shrinkage and approximately one half that of resins. (23,24,25)

The different results in the above mentioned studies may be due to the conducted in vitro studies in which the oral conditions were not considered. This is very clear from the study conducted by Abdalla and Davidson. (26)

In the dental literature there is no consensus about the effect of saliva contamination on the quality of the bond of glass ionomer restorations. Results reported range from no effect of saliva contamination on enamel and dentin bond strength (8) to some effect on marginal integrity (9) to substantial bond strength reduction that cannot be recovered with rinsing or etching. (10)

The findings of the current study revealed that all types of glass ionomers showed higher percentage of gaps when subjected to salivary contamination especially when saliva contamination occurred after the application of the conditioner as shown in fig (1).

In contrast to our findings, other investigations (10,27,28,29) demonstrated that salivary contamination reduced bond strength. Previous findings clearly indicate that even short-term salivary contamination of the tooth surface strongly interferes with the obtainable bond strength. Saliva composition includes inorganic compounds, enzymatic molecules and organic macromolecular, proteinaceous compounds. (30) Thus, even a short-term application of saliva to the tooth surface and subsequent air drying will result in protein adsorption and the formation of the initial (basal) pellicle layer. (31)

In contrary to our findings, some investigations (32,33,34) found that saliva contamination (followed by air drying) did not significantly affect the mean bond strength. The possible explanations given were the presence of adhesive proteins in saliva or that saliva did not wet the surface and became immediately detached. It is also possible that the water content of saliva helps to maintain the structure of the collagen so as not to adversely affect bonding.

This controversy in the evaluation of the effects of saliva contamination might be related to the variety of the tested materials, the different cavity designs, the different test methods or the properties of the hard tissue.

5. Clinical significance:

Nano-Ionomer showed least marginal gaps and better marginal adaptability when compared to CGIC and RMGIC. Salivary contamination reduced marginal adaptation of different glass ionomer restorative materials especially after conditioner application.

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