ORIGINAL ARTICLE

COMPUTATION OF THE GAP SIZE AT THE MARGINAL INTERFACE OF TWO TYPES OF FISSURE SEALANTS: AN IN VITRO EXPERIMENTAL STUDY

Tabinda Nawaz Khan[1], Farhan Raza Khan[2], Muhammad Fahad Riaz[3]

[1]Department of Science of Dental Materials, Dow Dental College, Dow University of Health Sciences, Karachi-Pakistan
[2]Dental Section, Department of Surgery, Aga Khan University, Karachi-Pakistan
[3]Metallurgy and Materials Engineering Department, Dawood University of Engineering and Technology, Karachi (DUET)-Pakistan

Background: The occlusal surface, prone to dental caries due to pits and fissures formed by imperfect enamel coalescence, is commonly protected using fissure sealants. This study evaluated the gap size at the tooth-sealant interface for two sealant types, with and without enameloplasty. **Methods:** An in vitro experimental study was conducted at Dow Dental College, Karachi. Forty-four extracted human molars and premolars were divided into four subgroups based on sealant type—light-cured flowable resin-based or resin-modified glass ionomer cement (RMGIC)—and whether enameloplasty was performed. Specimens underwent thermocycling, sectioning, drying, and gold sputtering. They were examined at 50× magnification using scanning electron microscopy. Slides showing gaps between sealants and tooth structures were analyzed. One-way ANOVA tested the mean gap differences, with significance set at $p \leq 0.05$. **Results:** The overall mean gap observed was 22.38±14.33 µm. The largest gap (30.68±17.76 µm) appeared in RMGIC without enameloplasty; the smallest (12.12±7.03 µm) in flowable resin with enameloplasty. RMGIC with enameloplasty and flowable resin without enameloplasty showed comparable mean gap sizes (20.51±8.04 µm). Differences among groups were statistically significant ($p=0.007$). **Conclusion:** Flowable resin-based sealants created smaller marginal gaps than RMGIC. Enameloplasty significantly reduced gaps in both sealant types, with the most pronounced improvement observed in the flowable resin group.

Keywords: Marginal gaps; SEM; Sealants; RMGIC

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INTRODUCTION

The most affected site for development of dental carries is the occlusal surface.[1] The occlusal surface may have pits and fissure formed due to non-coalescence or imperfect coalescence of the developing enamel lobes.[2,3] Use of fissure sealants is a commonly employed method of protection against pits and fissures caries.[4,5] Unfortunately there is no ideal material that could be used for the sealing purpose.[6] Resin based composites and the glass ionomer based sealants are the two common varieties of pits and fissures sealants used in clinical practice.[7] The enameloplasty is a procedure that is used to modify the enamel surface, essentially, it's done to increase the enamel surface area by opening up of the pits and fissures so that sealant material gets better adapted with the tooth surface. However, it's not always possible to achieve a perfect adaption owing to variable anatomy of the pits and fissures.[8] The present study is aimed to assess the marginal gaps formed at the tooth-sealant interface arising from the imperfect adaptation of the sealant material in teeth treated with or without enameloplasty.

MATERIAL AND METHODS

This study was an in vitro, an experimental study conducted from July to December 2020 at Dow University of Health Sciences and NED University, Karachi, Pakistan. The collection of twenty extracted human molars and premolars was done from the subjects whose teeth were already scheduled for extraction for other reasons (orthodontic extractions and periodontal reasons). Teeth with enamel defects, malformed, cracked, fractured crowns or teeth any previous filling were excluded. Similarly, teeth that had caries, erosions, restorations, and attrition were also excluded. The collected teeth were subject to manual cleaning with pumice water and then were stored in normal saline at 4°C for 48 hours.

The sample size was calculated using the software "sample size determination in health studies by WHO". An option of two-sided hypothesis testing of a population mean was employed. With a test value and anticipated mean were taken as 30 and 10 µm, level of significance 0.01 and power 0.80. The sample size requirements turned out to be 11. Since we had four groups, the number of observations needed was 44.

The selected teeth were then randomly assigned to four study groups where the number of specimens in each of the study groups ranged between 10 and 12. The groups were based on the type of fissure sealants (RMGIC or RBC) employed and whether the enameloplasty was done or not. For enameloplasty, a small pear-shaped diamond bur, No. 330 (Swiss Tec, Switzerland,) was employed using a high-speed handpiece. The dimensions of the enameloplasty were dictated by the size of the bur that is 0.80 mm width, 8 degrees taper, and 1 mm depth. In the flowable sealant group, before the application of flowable resin (Filtek Flow; 3M-ESPE, St. Paul, MN, USA), the tooth was etched with 37% phosphoric acid, (Ultradent, USA) for 15 seconds. After washing and drying teeth with an air-water syringe, Adper single bond adhesive (3M-ESPE, St. Paul, MN, USA) was applied and cured as a primer to enhance the bonding of sealant. The Filtek flow was applied and light cured for 20 seconds. In the RMGIC sealant group, the RMGIC (Vitrebond light cure; 3M-ESPE, St. Paul, MN, USA) applied over the cleaned occlusal surface of teeth. It was air-thinned and then light-cured for 40 seconds.[9] Thermo-cycling was performed simulating the clinical aging of the samples. In this respect, a controlled digital water bath (Human Lab Instrument Co, Korea) and the crushed ice container in a refrigerator were used to maintain a dwelling timing of 30 seconds. The two water baths regulated the temperatures of 60±2 °C, and 37±2 °C, while the crushed ice container in a refrigerator, maintained 4±2 °C. The specimen teeth were sectioned at the crown-root junction near cemento-enamel junction and then were poured into epoxy resin. Upon hardening, resin blocks were formed that were suitable for sectioning. Crowns sections were made bucco-lingually, using a diamond cutting saw (EQ MT 4, MTI Cooperation, USA). Specimen slides were examined using an analytical Scanning Electron Microscope [SEM] (JEOL JSM 6380LA, Japan). Before examination, the specimens were dried under sunlight for 24 hours and sputter coated to make their surface metallic, with gold-palladium in JEOL JFC-1500 auto fine coater for 120 seconds. A total of 44 slides were selected for examination by a trained assessor who observed the specimen slides under the magnification of 50 to 200X. The gap at the tooth-sealant interface was calculated using the scale function in the microscope. The ANOVA was applied for the computation of the mean differences between the gap size observed in the two varieties of fissure sealants placed with or without enameloplasty. The level of significance was kept at 0.05.

RESULTS

The overall mean gap observed in the study was 22.38±14.33 µm (Table-1). The largest mean gap size (30.68±17.76 µm) was seen around the RMGIC sealant placed without enameloplasty while the smallest gap (12.12±7.03 µm) was observed in the flowable resin sealant placed with the enameloplasty. The RMGIC with enameloplasty and flowable resin without enameloplasty exhibited somewhat similar gaps widths (20.51±8.04 and 20.51±8.04). The gap sizes amongst the study group were significantly different (*p*-value 0.007) with RMGIC sealant without enameloplasty showing the largest marginal gaps than the rest of the groups. It was further observed that most of the gaps were found at the bottom of the fissures while the interfaces at the lateral margins remained largely intact.

DISCUSSION

The present study is aimed at computing the marginal gaps at tooth-sealant interfaces of two commonly placed fissure sealants placed with or without the enameloplasty technique. It was observed that the RMGIC sealant placed without enameloplasty exhibited the largest marginal gaps a mong all study groups. Figure 2 (a, b & c) showed a loss of adaptability due to breakage in the bonds. While figure 2 (d, e & f) showed a deficient primer responsible for the loss of adaptability. The relatively large size of the marginal gap in this study group can be attributed to the low contact angle of the sealant material with the tooth surface. Unlike flowable composite, the RMGIC has inferior flow properties. This could have prevented the proper adaptation of sealant material in the fissure anatomy. Flowable resin-based sealants placed with the enameloplasty showed the smallest gaps among all four groups. Figure 3a showed a loss of adaptability at the bottom of the fissure, while the gap was so small in figure 3 (d) that the scale was unable to measure it. Figures 3(b, c, e & f) showed that the deficient adhesive was responsible for the loss of adaptability.

However, RMGIC with enameloplasty and flowable resin-based sealants placed without enameloplasty exhibited similar width of the marginal gaps (table 1). Figure1 (a, b & c, d & e) showed a deficient bond is responsible for the loss of adaptability in RMGIC with enameloplasty group whereas figure 1 (f) showed porosities at the bottom of the fissure. Regarding flowable resin-based sealants placed without enameloplasty, figures 4 a, b & c) showed loss of adaptability due to breakage in bonds while figure 4 (d) showed the continuation of vertical cracks that lead to loss of adaptability. Figures 4 (e & f) showed a deficient adhesive responsible for the loss of adaptability.

RMGIC sealant with enameloplasty showed the failure of adaptation of materials. It also showed only one interface (bottom of left fissure) when the material is completely intact (at the right one.) Vertical cracks can be seen throughout the material. These cracks were terminated where they touched the bond or primer, while the interface adaptability was found lost at the places where this bond or primer was inadequate.

It is evident from the literature that the microleakage is primarily associated with the marginal interfaces[9,10] and not the bottom of fissures[6,11]. In the present study, it was observed that at most of the sites, margins were intact while fissure sealant were displaced from the bottom of fissures. Another observation in the study was that the maximum gap observed was less than

50 microns, which is considered a minor issue in leakage studies.[12] Recently Qamar Et-Al showed that the actual issue is not the bacteria, but the toxins released by the bacteria when leach into the fissures are responsible for the failure of fissure sealants.[13] It has been established that if the margins of the sealants are fully intact, then the retention of the sealants will be predictable and so is the caries prevention. Many attempts have been made to understand the phenomena of adhesion of sealants in the tooth and to make restoration leakage-free.[14–16] But still, neither any dental material nor any technique has promised an absolute success.[16,17] Among interventions to improve sealant retention, enameloplasty has been advocated as a predictable solution, but it has debatable outcomes.[2,16,18,19] Some clinicians are its proponent[18,19] whereas others are opponent, claiming that it has the potential to worsens the microleakage[2,16]. There are other studies that neither support nor discourage this procedure.[20,21] In the present study, enameloplasty showed a positive impact on the adaptability of sealants in fissure. This could be attributed to the increase in the surface area of the tooth resulting from enameloplasty, thus making more surface of the tooth available for adhesion with the sealant material. Moreover, increased surface area resulting from enameloplasty also helped to raise the surface energy for bonding, thereby reducing the gap size at tooth-sealant interface.In the light of the above findings, it can be concluded that the present study showed that smaller marginal gaps were found when enameloplasty was done. The main reason of getting small marginal gaps with enameloplasty was due to the better application of primer/ adhesive. Although due to desiccated and brittle nature of RMGIC, (one can see pores in Fig 1 and 2) the material is not much promising to give a better seal in thin fissures.[2,16] The present study was an invitro study and thus has its limitations. Moreover, an important variable that is not accounted for in invitro study design is the clinical handling of the material. The clinical outcome in sealants adhesion largely depends on salivary control, cleanliness of the tooth, clinicians' manual dexterity, and the experience.

Table-1: Mean marginal gap around two sealants placed with or without enameloplasty as observed under SEM.

Study Group	n	Mean gap width (µm)	Minimum gap width (µm)	Maximum gap width (µm)	*p*-value
Group 1: RMGIC with enameloplasty	12	20.51±8.04	10.0	32.75	
Group 2: RMGIC alone	12	30.68±17.76*	8.28	66.50	
Group 3: Flowable resin with enameloplasty	10	12.12±7.03	6.88	27.50	
Group 4: Flowable resin alone	10	20.77±12.34	6.0	44.0	**0.007****
Mean marginal gap at tooth-sealant interface	**44**	**22.38±14.33**	**6.0**	**66.50**	

ANOVA was applied 0.05 level of significance.
*Tucky's Post hoc test suggested that RMGIC with no enameloplasty had the highest marginal gaps
**Highly significant difference among the study groups

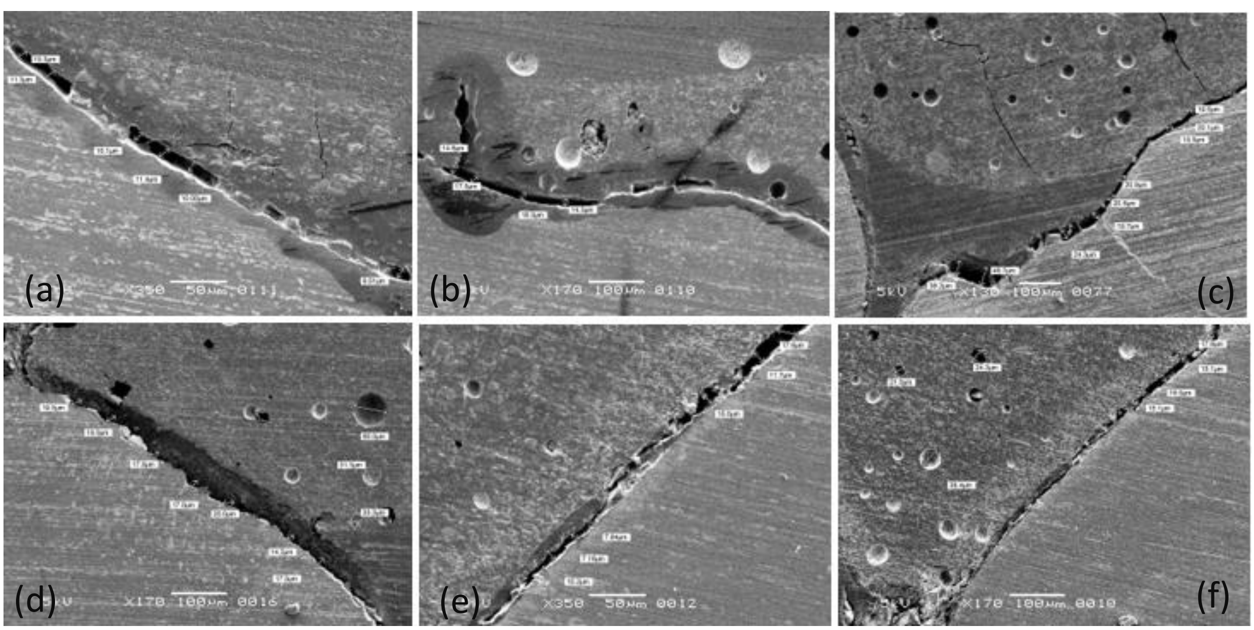

Figure-1: Measurement of the gap width in Group 1 (RMGIC with enameloplasty). Fig. a, b & c, showed loss of adaptability due to breakage in bond while fig d showed continuation of vertical crack leading to loss of adaptability. Fig. e & f showed deficient primer that is responsible for loss of adaptability.

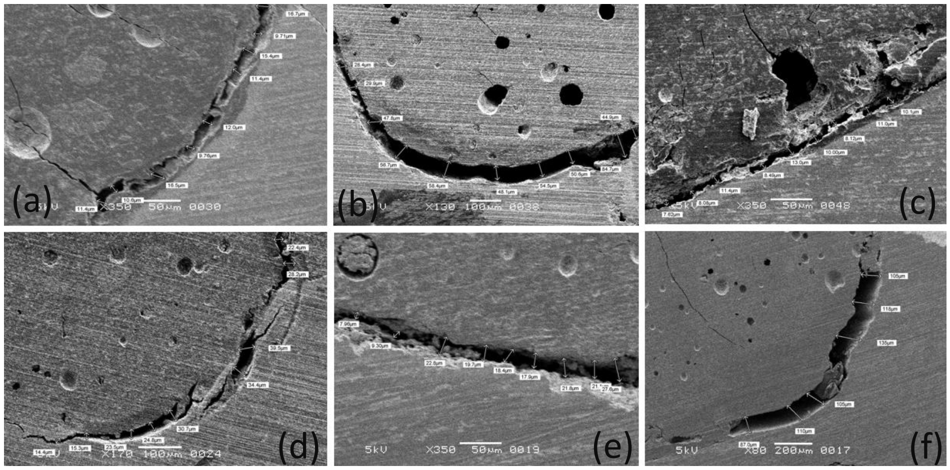

Figure-2: Measurement of the gap width of Group 2 (RMGIC alone). Fig. a, b & c showed loss of adaptability due to breakage in bond while Fig. d, e & f showed deficient primer that is responsible for loss of adaptability.

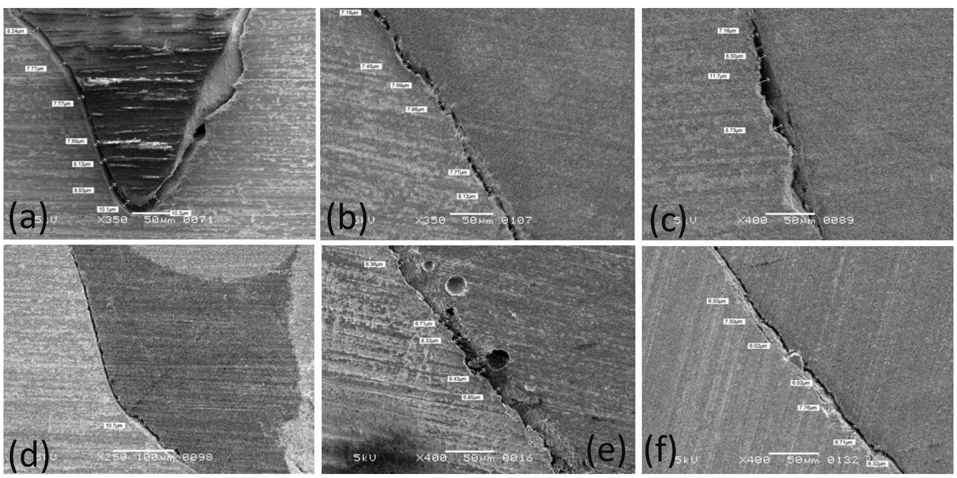

Figure-3: Measurement of the gap width of Group 3 (resin with enameloplasty). Fig. a showed loss of adaptability at the bottom of fissure, while gap was so small in fig d that computer was unable to measure it. Fig. b, c, e & f showed deficient bond that is responsible for loss of adaptability.

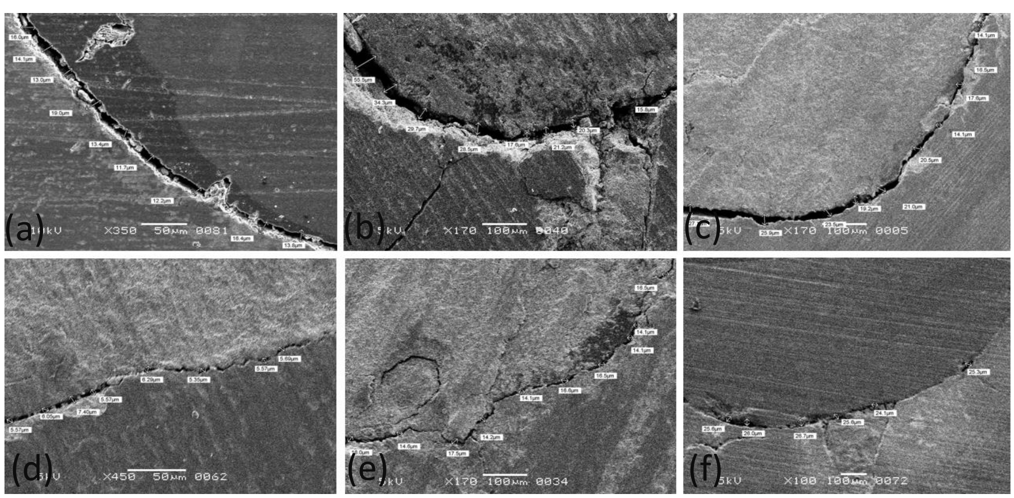

Figure-4: Measurement of the gap width of Group 4 (resin alone). Fig. a, b & c, d & e showed deficient bond that is responsible for loss of adaptability while fig. f showed porosities at the bottom of fissure.

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AUTHORS' CONTRIBUTION

TNK: Conceived the idea, literature review, data collection, write-up. FRK: Data analysis, critical review. MFR: Literature review, sample analysis.

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Address for Correspondence:

Dr. Tabinda Nawaz Khan, Department of Science of Dental Materials, Dow Dental College, Dow University of Health Sciences, Karachi-Pakistan

Cell: +92 300 232 4728

Email: tabinda.nawaz@duhs.edu.pk