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Correlation between Marginal Gap Width and Wear of Luting Cement in Class I Inlay Restoration of Permanent Molar Teeth

[1] **Md. Asaduszaman,** [2] **Salma Aktar,** [3] **Rozina Akter,** [4] **Mozammal Hossain**

[1] Assistant Professor, Conservative Dentistry & Endodontics, Faculty of Dentistry Bangabandhu Sheikh Mujib Medical University Dhaka, Bangladesh

[2] Assistant Professor, Department of Orthodontics, Holy Family Red Crescent Medical College, Dhaka, Bangladesh

[3] Medical Officer, Conservative Dentistry & Endodontics, Faculty of Dentistry Bangabandhu Sheikh Mujib Medical University Dhaka, Bangladesh

[4] Professor, Conservative Dentistry & Endodontics, Faculty of Dentistry Bangabandhu Sheikh Mujib Medical University Dhaka, Bangladesh

Corresponding Author: **Mozammal Hossain**

Abstract
This experimental study evaluated the correlation between the marginal gap width and wear of luting cement in class I inlay restoration. Fifty Class I inlay restorations were cemented either with a single step self-etch adhesive or resin-modified glass ionomer luting cement. Following cementation of inlay, an impression was taken and epoxy resin was applied on the impression, and then measured the gap width between the tooth tissue and inlay restoration, and wear of luting cement by using a scanning electron microscope at baseline, after 3, 6, and 12 months. Data was collected and the correlation between marginal gap width and wear of luting cement was assessed as well as the differences between the wear of two luting cement were performed by student t-test; a value of $p < 0.05$ was considered as statistically significance. It was found that the wear of luting cement was increased with the increase of marginal gap width. Furthermore, the wear of self-adhesive resin cement was statistically significant than that of resin-modified glass ionomer cement. In conclusion, the wear of luting cement increases in large marginal gap width and self-adhesive resin cement showed low wear than the resin modified luting cement.

Keywords: Inlay Restoration, Marginal Gap Width, Luting Cement, Wear, Correlation

Introduction
Dental resin composites were originally introduced in dentistry as direct anterior restorative materials. However, the development of technological improvements, its use in restoring the posterior teeth has been expected. There are several causes for failure of the direct composite restorations but the major cause with the earlier posterior composites was poor wear resistance [1]. Furthermore, the newest direct composite resin offers excellent optical and mechanical properties, its use in larger posterior restorations is still a challenge due to the polymerization shrinkage of the material into the cavities. Although, the advances in adhesive systems could reduce the risk of polymerization stresses in enamel-free cavity margins, the improper sealing of the restorative material with the tooth tissue results in microleakage, postoperative sensitivity, and recurrent caries [2, 3]. Furthermore, the achievement of a proper interproximal contact and the complete cure of composite resins in the deepest regions of a cavity are other challenge related to direct composite restorations. Various approaches have been developed to improve some of the deficiencies of direct placement composites, [4, 5] but no method has eliminated the problem of marginal microleakage associated with a direct composite filling [2].
Indirect resin composites were introduced in operative dentistry to reduce the polymerization shrinkage by improving the properties of restorative material. Comparing with the direct resin composites which were mainly composed of the organic resin matrix, inorganic filler, and coupling agent, the first generation indirect restorative composites had a composition identical to that of the direct resin. For inlay composites, an additional or secondary cure is given extra orally, which improves the degree of conversion and also reduces the side effects of polymerization shrinkage. It was observed that the first generation indirect restorative composites showed improved properties only *in vitro* studies but had a failure in clinical studies [6].
Furthermore, it showed poor clinical performance due to scarce bonding between organic matrix and inorganic fillers which

results in unsatisfactory wear resistance, high incidence of bulk fracture, marginal gap, microleakage, and adhesive failure in the first attempts to restore posterior teeth. To solve the problem, an increase in the inorganic filler content, reduction of filler size, and modification of the polymerization system were introduced in the second generation composites with micro-hybrid filler. By increasing the filler load, mechanical properties and wear resistance is improved, and the polymerization shrinkage is reduced [7]. The new composite resins contain high amounts of filler contents, which make them adequate for restoring posterior teeth.

Ceramage is a micro-ceramic polymer system with 73% of zirconium silicate filler (PFS-Progressive Fine Structured filler) supported by an organic polymer matrix which ensures a durable surface quality with the excellent polishability and high resistance to plaque. It can be expected that ceramge can be used as an indirect restoration (e.g., Inlay restoration) with better clinical outcome but the marginal degradation around restorations that occur after a period of time represents a potential reason for inlay restorations failure [8]. Furthermore, microleakage of cariogenic bacteria between the cavity walls and restorations is reported to be a significant cause of pulpal inflammation, pulp necrosis [9-12] and secondary caries [13, 14] The sign of microleakage also include immediate postoperative sensitivity, chronic sensitivity, and marginal discoloration [15-17].

Previous studies have indicated that the common factors of marginal degradation of inlay restoration are loss of luting cement due to mastication, toothbrush abrasion, loss of adhesion with tooth tissue, and solubility of the luting cement [18, 19]. Therefore, it is considered that due to limited precision in marginal fit, the success of inlay restorations greatly depends on the luting cement used. Traditionally, zinc phosphate cement and glass ionomer cement are used as luting cement for cementing inlay restorations. However, these cement are not always effective in inlay cementation. Especially, the solubility of the traditional zinc phosphate cement and lack of adhesion decreases the longevity of metal inlay restoration [18, 19]. As possible alternatives to the traditional zinc phosphate and glass ionomer cement, the development of resin-modified glass ionomer, composite resin, self-adhesive resin cements increase the clinical outcome of the inlay/onlay when compare to zinc phosphate and glass ionomer cement [20]. Previous in-vitro studies also indicated that the physical properties of the new cement are superior to those of zinc phosphate and glass ionomer cement in the areas of strength [21-23]. Retention [23, 24] film thickness [24] and water solubility [25-26] However, it is still controversial whether or not self-adhesive resin cement and resin-modified glass ionomer luting cement are capable of reducing luting cement loss in inlay restoration which is needed to be justified. Therefore, the aim of this study was to assess the correlation between the marginal gap width and wear of self-adhesive resin cement and resin-modified glass ionomer luting cement by serial replica method.

Materials and Methods

This study was performed in Conservative Dentistry & Endodontics, Faculty of Dentistry, Bangabandhu Sheikh Mujib Medical University.

Subjects

The patients who had a carious lesion at the occlusal surface of the tooth were selected as inclusion criteria. Caries in the buccal and lingual surface, discolored and periodontally compromised teeth, a tooth with the developmental defect were excluded from the study. A total of 50 adults (age range: 18-50 years) with an occlusal carious lesion on the permanent molar was selected and then restored with ceramage inlay by using Self-adhesive resin and Resin modified glass ionomer luting cement respectively following manufacturers instruction according to the standard protocol for tooth restoration.

Preparation of Ceramage Inlay

The tooth surface was cleaned thoroughly to remove plaque and the operative field carefully isolated with a rubber dam, cotton roll and suction device. All inlay cavities were prepared by using 45 no. flat-ended fissure bur with maintaining standard protocol. The preparation of the cavity depth was 2-3 mm and the mesio-distal diameter was fixed in 2 mm. The occlusal walls were vertical or slightly (2-5 degrees) divergent. Inlay was prepared according to manufacturer's instruction as follows: an impression of the inlay cavity was taken with a silicone impression material and temporary restoration was placed into the inlay cavity. After the preparation of the model, a thin layer of ceramage spacer was applied on a prepared cavity with a supplied brush, followed by the application of ceramage separator. Ceramage was applied incrementally into the floor of the cavity and cured for 30 seconds in solidilite light box. Ceramage modeling liquid was applied in each increment and light-cured for 3 minutes and then build up of enamel by ceramage composite. After the build of enamel, ceramage oxy barrier was applied to avoid air contact and final curing was done for 3 minutes by tungsten halogen light. After curing, contouring of the restoration was done with the help of robot carbide fissure bur. Finally, finishing and polishing of the restoration were performed by cermage finishing and polishing kit.

Cementation

The temporary restoration was removed from the cavity, cleaned and dried and then the inlay was placed gently into the cavity either by self-adhesive resin (MaxceemEliteTM, USA) and resin-modified glass ionomer (Nexus TM RMGI, USA) cements. The surplus material was removed by using a dental probe. Self-adhesive resin was then polymerized for 10 seconds by tungsten halogen light. Finishing off the definitively set inlay was carried out using a super snap polishing kit. Occlusion and articulation assessment was carried out using articulating paper.

Assessment of Correlation Between the Marginal Gap Width and Wear of Luting Cement

Following cementation of inlay, an impression was taken at baseline, 3, 6 and 12 months and epoxy resin was applied on the impression. The replica was then observed by using a Scanning electron microscope to assess the correlation between the marginal gap width and wear of luting cement. Furthermore, the differences between self-adhesive resin cement and resin modified glass ionomer luting cement were also measured according to the same way with marginal gap width (Figure 1). Three self-adhesive and six resin modified glass ionomer treated participants did not come to their follow-up period and these samples were discarded from the study.

Statistical analysis

A student-t test was done for estimating the significant difference between the wear of 22 self-adhesive and 19 resin modified luting cement and a value $p<0.05$ was considered as statistically significant. Pearson correlation test was performed to correlate between gap widths and wear depth.

Results

The results of the marginal width and wear of luting cement at 3, 6 and 12 months are shown in table 1 and figure 1. It was found that marginal gap widths of 22 samples of self-adhesive resin varied from 92.4 to 185.6 µm (146.25 ± 26.81) and 19 resin-modified glass ionomer cement ranged from 92.60 to 188.70 µm (147.55 ± 27.30). The differences between the two groups were not statistically significant. The depth (wear) of 22 self-adhesive resin varied from 8.12 to 24.5 µm (16.74 ± 4.40) and 19 resin-modified glass ionomer cement ranged from 10.15 to 26.0 µm (20.25 ± 4.70). The differences between the two groups were statistically significant.

At 6 months, the marginal gap width of 22 self-adhesive resin cement varied from 94.4 to 188.4 µm (151.85 ± 27.93) and 19 resin-modified glass ionomer cement ranged from 95.1 to 190.6 µm (1153.40 ± 28.43). The differences between two groups were not statistically significant. The depth (wear) of 22 self-adhesive resin varied from 8.90 to 33.2 µm (19.50 ± 5.70) and 19 resin-modified glass ionomer cement ranged from 11.8 to 33.6 µm (23.98 ± 6.31). The differences between the two groups were statistically significant.

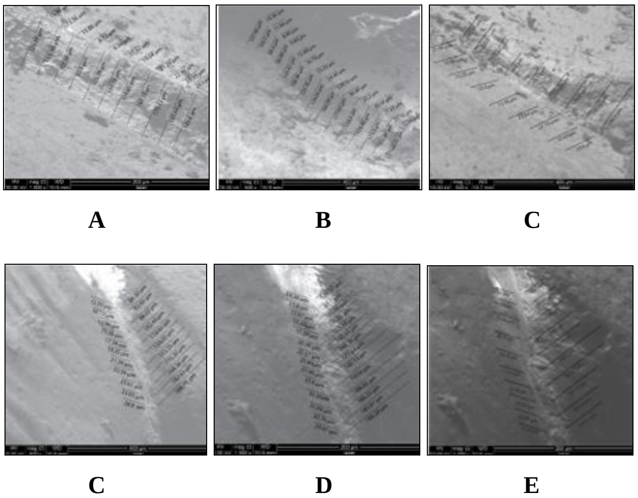
At 12 months, the marginal gap width of 22 self-adhesive resin cement varied from 98.4 to 190.4 µm (155.85 ± 25.87) and 19 resin-modified glass ionomer cement ranged from 99.7 to 198.5 µm (158.25 ± 21.28). The differences between the two groups were not statistically significant. The depth (wear) of 22 self-adhesive resin varied from 10.4 to 38.8 µm (20.46 ± 6.00) and 19 resin-modified glass ionomer cement ranged from 14.6 to 37.5 µm (29.76 ± 5.16). The differences between the two groups were statistically significant.

Table 1: Results of marginal gap width and wear depth and at 3, 6 and 12 months

	Self-adhesive (n=22)			Resin modified glass ionomer (n=19)		
	3months	6 months	12 months	3 months	6 months	12 months
Gap Width (µm)	146.25±26.81	151.85±27.93	153.07±27.49	147.55±27.30	153.40±28.43	155.17±29.24
Wear depth (µm)	16.74±4.40	19.5±5.70	20.74±5.81	20.25 ±4.70	23.98±6.31	25.55±6.50
Correlation between gap width and wear depth (y)	2.13+0.01*x	1.8+0.12*x	2.88+0.12*x	2.24+0.12*x	4.15+0.13*x	6.7+0.12*x

* Significant

Figure 1 showed the representative photographs of scanning electron microscope showing marginal gap width and wear depth in self-adhesive (Upper row) and resin-modified glass ioomer luting cements (Lower row). Self-adhesive at 3 (A), 6 (B), 12 months (C) and resin-modified glass ionomer luting cements at 3 (D), 6 (E) and 12 months (F)



Discussion

SEM analysis of replicas provided a clearer view of the degradation process. In both groups, an increasing wear of the luting composite was noticed from baseline to 12 months of the present study. Furthermore, ceramage inlay luted with either adhesive resin or glass ionomer luting cement showed almost similar gap width but the depth (wear) of luting cement were increased with the increase of gap width and the relationship was statistically significant.

The effect of luting cement gap width on their wear was observed *in vitro*, [27] and in other clinical trials [28-32].The mean widths of 116 to 169 µm were reported by Isenburg, *et al*. (1992) [28] and O'Neal, *et al*.(1993) [29], respectively. Furthermore, the present study also indicated that the wear of luting cements more pronounced when the luting gap was wider. This finding agrees with the reports by Leinfelder, *et al*. (1989) [33] and Van Meerbeek, *et al*. (1992) [8] that the larger widths are associated with extensive abrasion. It is likely that food particles penetrate the gaps during mastication, causing wear of the cement. With larger width, food particles may penetrate into the gaps during mastication, causing wear of the cement. On the other hand, in case of smaller gap width, food particles contact less cement surfaces mechanically during the mastication process. Once the widths increase, the number of food particles contacting the cement surface will increase and cause wear. It has been reported that a marginal width greater than 100 µm is associated with greater marginal leakage and an increase in secondary decay [29]. Therefore, the clinical acceptability of fit seems to require a gap narrower than 100 µm. However, some cases showed extensive abrasion of cement with widths less than 100 µm, when the cavity outline was in direct contact with opposing cusps or due to bruxism. This indicates that the cavity outline should not be placed in direct contact with opposing cusps.

The correlation between marginal gap width and wear of luting cement was also assessed by some of the previous studies. Guzman *et al*. (1997) [34] in their study indicated that vertical wear of the luting cement at the enamel interface increased linearly with marginal gap distance and significant differences in wear were found between the luting cements at wide marginal gap distances (240 microns) at the enamel interface. This is also supported by the present study. The type of cement also responsible for the wear. Shinkai *et al*. (1995) [35] reported significant relationships existed amongst marginal gap width, cement wear, and type of cement. Krämer N *et al* (2000) [36] indicated that the wear of luting composites could be reduced when using the higher filled luting material. Furthermore, regarding wear resistance of self-adhesive resin, an *in vitro* study of Belli, *et al*. (2009) [37] found that the wear resistance of self-adhesive resin to toothbrush abrasion was similar to conventional resin cement and flowable composites. Although increased wear was observed after 6 months of clinical functioning, this increased wear and marginal deterioration had no negative influence on the clinical functioning of the restorations. Longer-term evaluation should demonstrate if this marginal deterioration will become detrimental to the clinical performance of the restorations.

Conclusion

An increase of marginal gap width also increases the wear or loss of self-adhesive resin-modified glass ionomer luting cement and self-adhesive resin cement showed low wear than the resin modified luting cement.

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