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Effect of application site of definitive cement on marginal adaptation and retention of full metal crowns: An *in vitro* study

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Abstract
Background: Hydrodynamic pressure due to excess luting agent and insufficient seating pressure prevents complete seating of restorations. Incompletely seating may lead to disturbances in occlusion and interproximal contacts, decreased retention, open margins and recurrent caries. Decreased area of application of luting agent can improve marginal fit. However, its effect on retention of the prostheses is unclear.
Materials and Methods: In the *in vitro* study, marginal discrepancy and retention of full metal crowns were measured in 20 extracted human molars, divided into 2 groups, with a variation in application of luting agent.
Results: Test statistics showed a statistically significant difference between the two groups, both in retention and marginal discrepancy.
Conclusion: Decrease in the amount and area of application of the luting agent significantly decreases the marginal discrepancy of a cemented full crown. However, it also significantly reduces the retention, due to decrease in the bonding area.

Keywords: dental cement, dental marginal adaptation, luting agent, retention, tensile strength

1. Introduction
Failure in fixed prosthesis can occur despite meticulous planning and execution in tooth preparation, impression making, and all aspects of fabrication. The reason for such failure is more often than not, an improper cementation procedure. Improper loading of a crown with luting agent and insufficient seating pressure can lead to entrapment of luting agent between the tooth and the restoration, resulting in hydrodynamic pressure which prevents complete seating of the restoration. Failure to attain a completely seated crown may lead to disturbances in occlusion and interproximal contacts, decreased retention, open margins and recurrent caries.
Moore JA *et al,* 1985 [1] stated that occlusal or vertical height of otherwise well-fitting crowns increased significantly after cementation. The various factors that affect the marginal fit and retention of full crowns are type of luting agents[2,3,4], volume of luting cement used [5], marginal design [6], loading technique of luting agent and seating pressure [7], burs used in and taper of tooth preparation [8]. Olivera AB *et al,* 2006 [9] studied the effect of die spacer on retention and marginal fit of a crown and stated that increasing the area of die covered with spacer, increased the amount of retention and marginal fit.
Various cementation protocols are advocated to maximize crown seating, marginal fit and retention. Using minimum volume of cement with a brush on application was found to produce least marginal discrepancy. [5, 10] Application of luting agent along the margins resulted in significantly higher marginal adaptation. Lesser area of contact of luting agent can lead to lesser bond strength and decreased retention of the crown. However, none of the studies assessed the effect of these cementation protocols on retention of full crowns. The present study was conducted to study the effect of application site of definitive cement on the marginal adaptation and retention of full metal crowns.

2. Materials and methods
20 extracted human molar teeth with no evidence of caries and restorations were selected for the study. The range of buucolingual and mesiodistal width of the teeth selected was 9mm to 11mm and 8mm to 10mm respectively. The teeth were scrubbed with a tooth brush and plain water.

2.1 Tooth Preparation
Each tooth is mounted on an autopolymerising resin block. All the 20 teeth are prepared for a full metal crown with a chamfer finish line on all the aspects. A high speed aerotor hand piece, secured rigidly on a milling machine, was used to establish a uniform 6^0 taper in the tooth preparation. The autopolymerising resin block, with tooth, is secured to the cast mounting table of the milling machine. The table is rotated against the diamond abrasive for axial tooth preparation. The occlusogingival dimension, for all the specimens, is maintained at a standard of 3mm. To maintain uniform roughness of the prepared tooth surface for all the 20 samples, a new diamond abrasive point- TR 12 (MANI diamond bur, Kongsin Medical device Co. Ltd) was used for each sample. The occlusal surface is prepared flat and parallel to the floor.

2.2 Metal crown fabrication and cementation

Addition silicone impressions (Aquasil Ultra, light and medium – heavy body, Dentsply caulk) of all the tooth preparations were made and poured in die stone, two coats of die spacer was applied, wax patterns for full metal crowns were made, invested and casted. Metal crowns were made with a metal ring on the occlusal surface to facilitate testing on the universal testing machine. Metal crowns were finished, sandblasted and seated on the dies. Two circular dots were marked, one on the buccal aspect of the prepared tooth, apical to the finish line and the second on the buccal aspect of the metal crown, occlusal to the crown margin [Figure 1]

The specimens were randomly divided into 2 groups of 10 each. The prepared teeth in Group 1 received metal crowns with Glass Ionomer Cement applied on all the internal surfaces of the crown. [Figure 2] The prepared teeth in Group 2 received metal crowns with Glass Ionomer Cement applied on all the internal surfaces except the occlusal surface. [Figure 3] A single investigator manipulated Type I Glass Ionomer Cement (GC Fuji I), applied a thin layer on the internal surfaces of the metal crowns. The crowns were cemented onto the prepared teeth with firm finger pressure till the initial set. After 24 hours, the specimens were immersed in distilled water and stored for 1 week.

2.3 Measurements to assess marginal adaptation

Before the metal crowns were cemented on the prepared teeth, the distance between the two dots (one on the buccal aspect of the metal crown and one on the buccal aspect of the tooth) on each of the 20 specimens was measured using a measuring microscope with a least count of 1µm. The measuring microscope had an inbuilt camera (Camera Clemex L 1.3M) to capture images of the specimen in focus.[Figure 4] A software program (Clemex CMT), was used to view the image on a computer screen and perform required tasks for measurement. The distance between the dots was measured between the internal tangents drawn against each circular dot. The readings were taken thrice and a mean recorded. Similar measurement was done on all the 20 specimens, 24 hours post cementation. Comparison of the distance, between the dots, before and after cementation was done to assess the marginal adaptation of the metal crowns post cementation. The difference in the measurements gives the marginal opening of the crown or the discrepancy in adaptation of the crown to the finish line, post cementation

2.4 Tests for retention

The specimens immersed in distilled water for a week were then tested for retention of the full metal crowns. A universal testing machine calibrated to a cross head speed of 0.5mm per minute and with a tensile load of 500KN, was used to test all the 20 specimens. [Figure 5] The tensile force (MPa) needed to debond the metal crowns was recorded.

The values of Tensile Strength (TS MPa) and Marginal Discrepancy (MD µm) were tabulated and statistically analyzed using the Mann- Whitney test (Non-Parametric Test)

3. Results & Discussion

Descriptive statistics [Table: 1] for amalgamated data of Group 1 and 2 for Tensile strength and Marginal discrepancy show a maximum and minimum tensile strengths (for debonding of specimens) of 4.2 MPa and 6.3 MPa with a standard deviation of 0.477. The maximum and minimum marginal openings seen in both the groups are 152.2µm and 55.4µm with a standard deviation of 39.34.

The ranks table [Table 2] shows that the mean rank tensile strength of 14.6 in Group 1 is considerably higher than the mean of Group 2 which is 6.4. The mean rank marginal discrepancy of 15.5 seen in Group1 is also higher than 5.5 of Group 2.

The test statistics [Table 3] show that there is a significant difference between the two groups in tensile strength values (U =9.000 p=.002) and a highly significant difference between the two groups in marginal discrepancy values (U=.000 p=.000)

4. Discussion

The *in vitro* study design was chosen because of the advantage it offers in measuring marginal discrepancy or marginal opening created after crown cementation, which in vivo is non-existent. Extracted human teeth used in the present study simulate the intraoral tooth surface better than typhodont teeth. Though there is great variance in size and hence the surface area of bonding of each specimen, presence of natural tissues (dentin) facilitates replication of intraoral bonding characteristics *in vitro*.

The two variations in cement application were chosen in this study to observe the effect of luting technique on the marginal opening created due to incomplete seating of full crowns, post cementation. 2007. Glass Ionomer Cement was selected as it is the most commonly used definitive cement.

Asif *et al*, 1987 [11], Cardoso M *et al*, 2007 [12], Cruz MA 2008 [14] and Wadhwani C *et al*, 2012 [10] studied variation in cement application site, volume of cement application, static and dynamic loading and venting mechanism to arrive at ways to decrease marginal discrepancy in full crowns during cementation. Cruz *et al*, demonstrated that best seating is achieved by venting and tapping of crowns. Asif *et al*, [11] and Cardosa M *et al*, [12] concluded that the best marginal adaptation during cementation is achieved when luting agent is applied on the internal surface only along the margins. However along with the improvement in marginal adaptation with these techniques, there is a possibility of decrease in crown retention because of the decreased area of flow of the cement. The present study aimed to determine the best possible cement application strategy to decrease marginal discrepancy, and also analysed the effect of variations in cement application on the retention of full crowns.

A highly significant difference (p =0.000), in marginal discrepancy values, was seen between luting cement application only on axial walls and cement application on axial walls and occlusal surface. Similar studies were conducted by Asif *et al*, 1987 [11] and Cardosa MA *et al*, 2007. [12] Both found statistically significant difference ($p<0.05$) in the application site of luting agent. The mean marginal discrepancy was 34.3µm when luting agent was applied only along the margins when compared to 144.5µm when cement was applied on the complete internal surface of the crown in the study by Cardosa MA *et.al*. [12] This is in accordance with the present study and shows that luting cement applied along a

smaller area of the internal surface, towards the margins, facilitates escape of excess cement and better seating of crowns. On the other hand cement applied all along the internal surface including the occlusal surface leads to improper seating of full crown due to inability of excess cement to escape.

Present study also showed that the tensile load needed to debond crowns with luting agent applied all over the internal surface was considerably higher (mean rank 14.6) than that needed (mean rank 6.4) to debond crowns with luting agent only along axial walls. A significant difference was seen (p=0.002). This implies that lesser area of contact of luting cement leads to lesser bonding strength and lesser tensile load required for debonding and vice versa. However this finding is not in accordance with previous studies by Covey DA *et al*, 2000 [15] and Tan KM *et al*, 2012 [5]. Covey DA *et al*, [15] studied the effect of increased abutment dimension on the retention of a prosthetic crown. They concluded that increase in surface area provided by a larger abutment did not significantly increase the retention of a restoration, when compared to an abutment with standard dimensions. Tan KM *et al*, [5] studied the effect of number and position of axial walls of an implant abutment on the retention of a crown. It was observed that abutments with 4 axial walls had significantly lower retention than 3 walls, 2 opposing walls and 2 adjacent walls.

To ascertain the findings of this study, further investigation with a larger sample size to assess the effect of variation in cement application on both marginal discrepancy and retention is required.

5. Tables and Figures

Fig 1: Dots on for marginal discrepancy measurement

Fig 2: Luting agent applied on all of the internal aspects of the crown

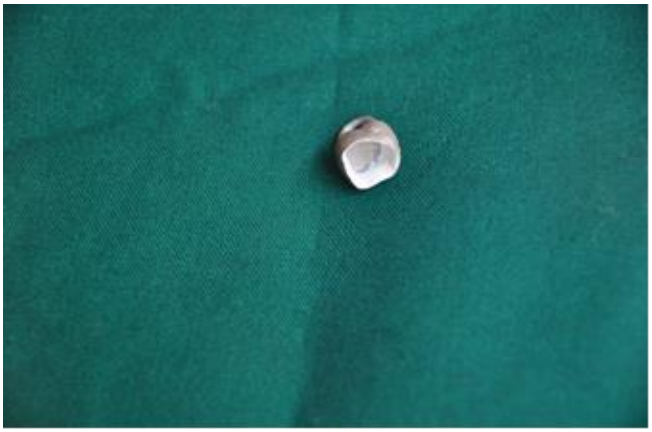

Fig 3: Luting agent applied only on the axial walls of the crown

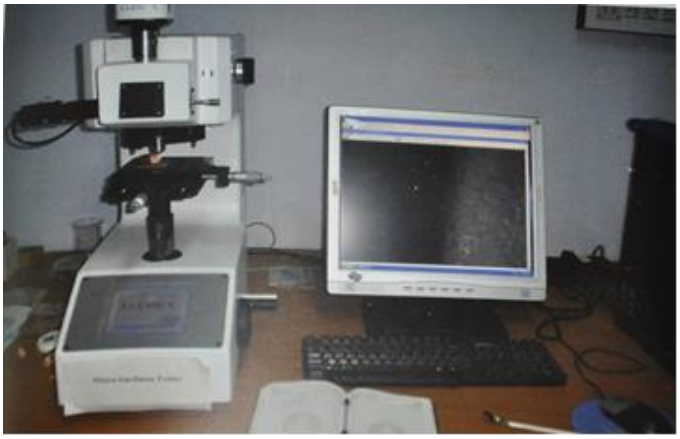

Fig 4: Measuring microscope

Fig 5: Universal Testing machine

Table 1: Descriptive statistics

						Percentiles		
	N	Mean	Std. deviation	Min.	Max.	25th	50th (median)	75th
TS (MPa)	20	4.727000	.4774174	4.2100	6.3400	4.342500	4.780000	4.930000
MD (µm)	20	102.8900	39.3496325	55.400	152.2000	63.100000	104.100000	142.000000
Group	20	1.50	.513	1	2	1.00	1.50	2.00

Mann – Whitney Test

Table 2: Ranks

Group	N	Mean rank	Sum of the ranks
TS (MPa) 1	10	14.60	146.00
2	10	6.4	64.00
Total	20		
MD (µm) 1	10	15.50	155.00
2	10	5.50	55.00
Total	20		

TS (MPa) -Tensile strength
MD (µm) – Marginal discrepancy
Group 1- received metal crowns with Glass Ionomer Cement applied on all the internal surfaces of the crown
Group 2- received metal crowns with Glass Ionomer Cement applied on all the internal surfaces except the occlusal surface.

Table 3: Test Statistics [b]

	TS (MPa)	MD (µm)
Mann – Whitney U	9.000	.000
Wilcoxon W	64.000	55.000
Z	-3.103	-3.780
Asymp. Sig. (2-tailed)	.002	.000
Exact Sig. [2*(1-tailed Sig)]	.001[a]	.000[a]

a. Not corrected for ties
b. Grouping Variable: Group

6. Conclusions

Decrease in the amount and area of application of the luting agent significantly decreases the marginal discrepancy of a cemented full crown. However, subsequent decrease in bonding area of the luting agent also significantly reduces the retention of the full crown.

7. References

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