

# Management of short clinical crowns by utilizing horizontal groove retentive technique in crown/tooth or both with different luting cements – An analysis on extracted teeth

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## ABSTRACT

**Purpose:** The aim of the present study was to compare and evaluate the retention of dislodged crowns by addition of one horizontal circumferential groove (HCG) to preparation and/or casting and with two luting cements. **Materials and Methods:** A total of 80 recently extracted human maxillary first molar teeth of appropriate sizes were collected and mounted in the resin blocks using surveyor. Standardized full coverage tooth preparations were prepared and impressions were obtained. Dies were prepared for casting and were then subjected to tensile loading using UTM. The data obtained was statistically analyzed. **Results:** Obtained values were statistically analyzed using ANOVA, STUDENT “t” TEST and BONFERRONI TEST. The results showed that the mean tensile force (TF) was in the range from 49.05 to 264.87 for group A and 255.06 to 588.60 for group B. The highest TF was recorded for subgroup 3B, whereas the lowest for subgroup 1A. **Conclusion:** Within the limitations of the study, it was concluded that by addition of one HCG to tooth preparation or casting and to both showed significant increase in retention, when compared to control groups. The highest retention value was obtained for sample with groove on the internal surface of crown luted with SARC.

**Keywords:** Circumferential groove, dislodged crown, self adhesive resin cement (SARC), tensile force, universal testing machine (UTM)

## Introduction

A plethora of restorations are used to restore form and functions of teeth which include intracoronal restorations, extra coronal restorations, fixed dental prosthesis, removable dental prosthesis, and implant supported prosthesis. Though implant supported

prosthesis revolutionized the field of dentistry for replacement of missing teeth, fixed dental prostheses are still the most frequent restorative procedures.<sup>[1]</sup>

Important factors relating to the success of a cast restoration are the design of the preparation of the supporting tooth structure and the accuracy of the casting. Other factors include the luting agent and its biomechanical characteristics, and the degree of bond strength between the cement and the tooth structure.<sup>[2]</sup>

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Complete cast crowns are good alternatives and have best longevity for the restoration of damaged posterior teeth. Occasionally, a crown with clinically acceptable margins, preparation design, and occlusion become improper. Clinicians often debate whether such a crown can be successfully recemented with any degree of confidence that it will not be dislodged under normal masticatory function. It has been documented that resistance form increases by placing grooves opposing each other in a crown and tooth; cements also have a role to play in retention of crowns.<sup>[3]</sup>

Traditional causes for premature crown dislodgment include loss of core structure, adhesive and cohesive failure of the luting agents, inadequate clinical crown preparation, failure to follow the manufacturer's directions for use of the luting agent and contamination of the luting agent and/or tooth preparation interface.<sup>[4]</sup> Moreover, failures may be a result of the inability of a cement to bond to the crowns as well as to tooth structure.<sup>[5]</sup>

It is not always possible to perform preparation modification on the external surface of prepared tooth as the remaining dentinal thickness can pose a challenge. So, horizontal circumferential retentive grooves placed on the internal surface of the crown is the safest option to aid in increased retention.<sup>[6]</sup>

The purpose of this *in-vitro* study was to determine that by adding horizontal groove to the internal surface of the crown and/or tooth preparation would improve retention of a complete metal crown and the cementation strength of their respective restorations upon cementation with conventional and adhesive cements.

## Materials and Methods

### Preparation of sample

A total of 80 recently extracted sound, non-carious, non-restored human maxillary first molar teeth were collected, cleaned and disinfected with 5% sodium hypochlorite solution. From the collected bulk, teeth with appropriate sizes were stored in distilled water till mounting. The teeth were mounted in the auto polymerizing acrylic resin block measuring 2 cm × 2 cm within 2 mm of the cemento-enamel junction [CEJ], with the long axis of the tooth perpendicular to the horizontal plane. After the resin had completely set, all the specimens were preserved in distilled water until further use. A mould was prepared to hold the mounted teeth in acrylic blocks which were then placed on a surveying table.

### Tooth preparation

Standardized full-coverage tooth preparation was carried out using a high-speed, high-torque airtor hand piece (NSK) manually in such a manner that the bur would remain parallel to the analyzing rod [Figure 1a]. The tooth preparations were done under copious water irrigation. All the prepared teeth were kept at least 4 mm in height. This was done by a single operator so as to ensure the uniform dimensions of prepared teeth. Following

the completion of the preparation, the specimens were again stored in distilled water till further use.

### Impression making and die fabrication

A special tray was fabricated and vent holes were placed to allow flow of excess material during impression making. Impressions of the prepared teeth were made with polyvinyl siloxane putty impression material (Flexceed soft putty/Regular set, Dentsply, Germany) using two-stage putty-wash technique. A total of 80 dies were poured. All the 80 dies were retrieved and checked for bubbles, voids, or any defects. Defective dies were discarded and impression was again poured and dies were prepared.

### Preparation of wax pattern and casting

After the application of Die hardener which was allowed to set for 2 minutes, two coats of die spacer were applied to dies, 0.5 mm above the prepared margin of the tooth. An extra layer of die spacer was added because the crowns had to be slightly loose on the die as it had to depict a crown dislodged from the mouth. Die lubricant was applied over the die.

The Wax patterns of 1–1.5 mm thickness were fabricated and a round wax sprue was shaped as a loop and attached to the occlusal surface of the wax pattern [Figure 1b] to make a connection for the tensile testing machine. Patterns were invested (Wirovest) and casting was done with Nickel-Chromium alloy in centrifugal casting machine.

Internal surfaces of all castings were examined for any casting defects. The internal surfaces of all crowns were sandblasted using sandblasting unit with the 110 μ aluminum oxide particles for 10 seconds at 20 kg/cm<sup>2</sup>.

### Grouping of the samples

All the samples were randomly divided into two groups of 40 samples each.

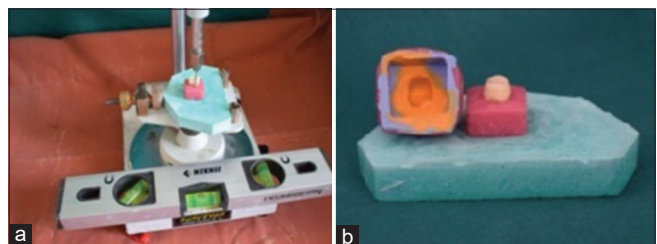
Group A: 40 samples

Group B: 40 samples

Samples of each group were cemented with glass ionomer cement and self-adhesive resin cement respectively.

Group A: cemented with Glass Ionomer Cement (GC - Gold Label)

Group B: cemented with Self Adhesive Resin Cement (G-CEM Link Ace)



**Figure 1:** (a): Surveying of mounted acrylic blocks. (b): Custom tray with impression and prepared tooth sample

Based on the placement of horizontal circumferential groove on the tooth and/or crown, each group was subdivided into four subgroups of 10 samples each

Subgroup I: Both casting and teeth were unaltered (control group) [Figure 2a]

Subgroup II: Casting had no groove, and the teeth had groove.

Subgroup III: Casting had groove and the teeth had no groove

Subgroup IV: Casting, as well as the teeth, had a groove

After the crowns were ready, preparation modifications were done on the external surface of the tooth and on the internal surface of the crowns. Castings were taken and one horizontal circumferential groove was made free hand on the internal surface of the crown. The groove was 0.5 mm deep and 1.4 mm wide with carbide bur. The groove was made approximately 3 mm from the cervical margin. Similarly, teeth were taken and one horizontal circumferential groove was made on the tooth with the depth orientation round bur approximately 3 mm from the cervical margin. Groove on the castings and teeth were placed in the same position to be opposite to each other while cementation.

Group A [cemented with GIC]

Subgroup I: Control group - Both crown and tooth without groove

Subgroup II: Crown without groove and tooth with groove

Subgroup III: Crown with groove and tooth without groove

Subgroup IV: Both crown and tooth with groove

Group B [cemented with resin cement]

Subgroup I: Control group - Both crown and tooth without groove

Subgroup II: Crown without groove and tooth with groove

Subgroup III: Crown with groove and tooth without groove

Subgroup IV: Both crown and tooth with groove

After applying the cement on the internal surface of the crown, the crown was seated on the respected prepared tooth using finger pressure for 60 seconds as it was meant to simulate what a dentist could do on chair side. The cement was allowed to set in a dry field for 10 minutes. The excess cement was removed with a curette.

The same procedure was repeated for cementation of all crowns to respective prepared samples.

Measuring tensile force

The samples were then subjected to the tensile loading using a universal testing machine. The sample was mounted in the lower jaw and the 19-gauge wire was held in the upper jaw by passing through the loop of crown [Figure 2b]. During testing the lower jaw moved in a downward direction. Force was applied by the testing machine at a cross-head speed of 150 mm/min, with a maximal vertical tensional

load of 40 KN. The maximal tensile force used to dislodge the crown was recorded in Newton. All the samples were tested [Figures 3 and 4] in the same manner and the values were recorded and subjected to statistical analysis.

Results

Descriptive statistical measures such as mean, range between maximum and minimum values of tensile bond strengths, standard deviation (SD), standard error of mean (SEM) were computed for all the study groups. In order to collectively compare the means of study groups, One-way ANOVA (analysis of variance) test was used ( $P < 0.05$ ) and pair wise comparison of the groups tested using student's "t" test ( $P < 0.05$ ) and multiple comparisons using Bonferroni test were done.

An analysis of variance (One-way ANOVA) of tensile bond strengths of specimens showed the statistically significant difference (Group A:  $F = 176.903, P < 0.001$  and Group B:  $F = 402.423, P < 0.001$ ) [Table 1].

On multiple comparisons using Bonferroni test [Table 2], the tensile bond strengths of specimens showed statistically significant difference.

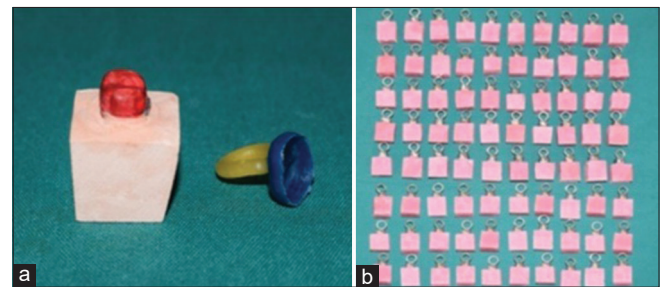


Figure 2: (a): Die sample with spacer coating and wax pattern with loop. (b): Acrylic blocks with castings

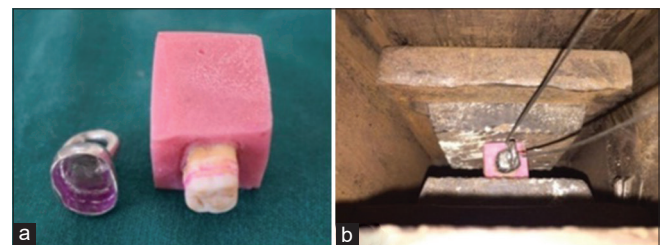


Figure 3: (a): Casting and tooth with groove. (b): Sample engaged with 19-gauge wire



Figure 4: Samples after testing

From the results obtained in the study,

1. The samples of subgroup 3B [samples with circumferential groove on the internal surface of crown luted with resin cement] showed significant increase in the retention when compared with the other group and within the group.
2. Within group Comparisons:  
 The samples of subgroup 3B showed a significant two-fold increase in the retention when compared to subgroup 1B [control group]  
 The samples of subgroup 3A [samples with circumferential groove on the internal surface of crown luted with GIC cement] showed a significant increase in the retention by three-fold when compared to subgroup 1A [control group].
3. Among groups comparisons:  
 The samples of subgroup 3B showed significant increase in retention by two-fold when compared to subgroup 3A.

On pair wise comparison using student's *t* test [Table 3] the tensile bond strengths of specimens showed statistically significant difference ( $t = 26.152, P < 0.001$ ;  $t = 33.093, P < 0.001$ ;  $t = 34.770, P < 0.001$ ;  $t = 28.945, P < 0.001$ ).

## Discussion

Primary care is healthcare provided in the community for people making an initial approach to a medical practitioner or clinic for advice or treatment. So short clinical crown is identified and treated with necessary modifications.

Mastication is not a process where forces act purely along the long axis of a prepared tooth, hence the resultant forces acting on the tooth were not only the compressive forces but also the tensile and shear forces, in order to overcome these forces or to prevent dislodgement of restorations, supplements should be provided either to the restoration or tooth and both if required to enhance the retention. Following an *in vitro* study was conducted to compare and evaluate the retention of dislodged crowns by the addition of horizontal circumferential groove to the casting and/or tooth preparation and with different luting agents i.e. GIC and Self-Adhesive Resin cement.

For the long-term and harmonious accommodation of restorative material, teeth require preparations which were based on Biological, Mechanical, and Esthetic principles.<sup>[7]</sup>

In this study, the retentivity of cast crown was obtained with one horizontal circumferential groove and two types

**Table 1: Multiple Group Comparisons of tensile force of two groups: ANOVA**

Parameters	Sum of squares	df	Mean square	F	P
<b>GIC</b>					
Between Groups	167123.611	3	55707.870	176.903	<0.001**
Within Groups	11336.613	36	314.906		
Total	178460.224	39			
<b>RESIN</b>					
Between Groups	386953.329	3	128984.443	402.423	<0.001**
Within Groups	11538.708	36	320.520		
Total	398492.037	39			

**Table 2: Multiple comparison of tensile force between the groups: Bonferroni test**

Variable	Sub group	n	Mean	Std. deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
GROUP A-GIC	SUBG 1	10	72.59	19.18	6.06	58.87	86.31	49.05	98.10
	SUBG 2	10	106.93	13.44	4.25	97.31	116.55	88.29	127.53
	SUBG 3	10	240.35	12.45	3.94	231.44	249.25	225.63	264.87
	SUBG 4	10	176.58	23.58	7.46	159.71	193.45	147.15	215.82
	Total	40	149.11	67.65	10.70	127.48	170.75	49.05	264.87
GROUP B - RESIN	SUBG 1	10	273.70	14.95	4.73	263.00	284.39	255.06	294.30
	SUBG 2	10	336.48	17.33	5.48	324.08	348.88	313.92	362.97
	SUBG 3	10	534.64	23.69	7.49	517.70	551.59	510.12	588.60
	SUBG 4	10	427.72	14.03	4.44	417.68	437.75	412.02	451.26
	Total	40	393.14	101.08	15.98	360.81	425.46	255.06	588.60

**Table 3: Group A vs Group B comparisons**

	SUBGROUP	n	Mean	Std. Deviation	Std. Error Mean	t	P	Sig
1.	GIC Control	10	72.59	19.18	6.06	26.152	0.000	**
	Resin Control	10	273.70	14.95	4.73			
2.	GIC Luted Tooth with Groove	10	106.93	13.44	4.25	33.093	0.000	**
	Resin Luted Tooth with Groove	10	336.48	17.33	5.48			
3.	GIC Luted Crown with Groove	10	240.35	12.45	3.94	34.770	0.000	**
	Resin Luted Crown With Groove	10	534.65	23.69	7.49			
4.	GIC Luted Tooth and Crown with Groove	10	176.58	23.58	7.46	28.945	0.000	**
	Resin Luted Tooth and Crown with Groove	10	427.72	14.03	4.44			

of luting agents i.e. conventional glass ionomer cement and resin cement.

The clinical success of fixed prosthesis also depends upon the luting agent and the proper cementation procedure. Dental cement must be used as a barrier against microbial leakage, sealing the interface between the tooth and restoration and holding them together through some form of surface attachment.<sup>[8]</sup> This attachment may be mechanical, chemical, or combination of both.<sup>[9]</sup>

One of the major causes for dislodgement of clinical crown is design of tooth preparation. Therefore, the design of the tooth preparation is an important consideration in the retention of crowns by geometrically limiting the number of paths along which a restoration can be removed from the tooth preparation.

In the present study, recently extracted non-restored sound natural maxillary first molar teeth of appropriate size were selected as they would have more open dentinal tubules when compared to carious and sclerosed teeth. This difference has an effect on the bonding of resin and glass ionomer cements to dentin.

More importantly, the use of natural teeth is clinically more relevant compared to alternative test specimens of metal dies or typhodont teeth. The true effect of resin bonding agents may be compromised in studies that do not use natural teeth.<sup>[10]</sup>

Kaufman *et al.*<sup>[11]</sup> determined the influence of preparation height on retention or resistance form and found a linear relationship between retention and preparation height, but the minimum preparation height studied was 4 mm, and the maximum retention was obtained at 1 degree of TOC (Total Occlusal Convergence), which is clinically unrealistic.

In the present study, care was taken to maintain proper taper and height during the tooth preparation through custom made platform using surveyor. Standardized tooth preparation was done following the principles of tooth preparation.

Zidan and Ferguson *et al.*<sup>[12]</sup> The configuration of finish line of the preparation affects the width of the band of cement exposed to oral fluids. Shoulder finish lines exposed more amount of cementing agent at the cervical margin, which also influences the fit of the restoration. According to Gavelis *et al.*<sup>[13-15]</sup> when chamfer finishing margin is used, the exposure of cementing agent decreases according to its inclination.

In the present study chamfer finish line was given in order to reduce cement exposure and to enhance fit of restoration.

Chan and Boyer *et al.*<sup>[16]</sup> in their study proposed the concept of auxiliary retention by placing opposing grooves in the castings and the cavity perpendicular to path of withdrawal and extending around the entire circumference of pattern midway between the

surface and the base. After cementation, grooves were occupied with cement. To dislodge the casting, fracture of cement or the dentine must occur.

The results of the present study were in accordance with Chan KC *et al.*<sup>[16]</sup> (1981), O'Kray H, Marshall TS *et al.*<sup>[14]</sup> (2012), Amarnath GS *et al.*<sup>[13]</sup> (2015), Krishna Kumar Lahoti *et al.*<sup>[6]</sup> (2017) who in their study concluded that placing 1 or 2 horizontal circumferential grooves into the internal surface of complete cast crowns increased the retention made for optimal tooth preparations. These results were attributed to the increased mechanical interlocking of the luting cement within the grooves which significantly increased the retention of the nickel chromium crowns.

Various authors categorically investigated that placing horizontal circumferential groove on the internal surface of complete cast crown would place some part of the cement interface under the state of compression. As most of the luting agents are weak in shear and tensile forces, cement in state of compression would help to increase the retention.<sup>[4,17]</sup>

Ideally, cement for restorations should have physical properties sufficient to resist functional forces over the lifetime of the restoration. In addition, cement should be resistant to degradation in the oral environment and adhere to the underlying dentin. These materials interact interfacially with the tooth structure and the crown substrates to create bonds. When a conventional glass ionomer is used, retention has been shown to be dependent primarily on the geometric form of the tooth preparation.<sup>[5]</sup>

In the present study, significant increase in retention was observed by placement of groove on the casting than on the tooth preparation and both. From this a clinician can provide better retention without involving or modifying the tooth preparation.

Conventional glass ionomer interacts interfacially with the tooth structure creating covalent bonds. Whereas the Resin cements have the ability to adhere to multiple substrates, high strength, insolubility in the oral environment, and shade matching potential.

Glass ionomer cements exhibit bond strength of 1.67 MPa, Resin cement is found to be the strongest one with the value of 2.33 MPa. The highest value of resin cement is quite understandable because of its bonding ability to tooth structure and metal surface. This could be attributed to the chemical nature of the cement to achieve micromechanical bonding.<sup>[18,19]</sup>

In the present study, loose fitting castings were prepared to replicate the clinical situation of dislodged crowns by coating additional layer of die spacer. For resin cement it was beneficial as it compensates the space due to its greater film thickness (40  $\mu\text{m}$ ).

Della bona and van noort[1998] and Nayakar *et al.*<sup>[8,9]</sup> stated that the shear tests were the most efficient to find out the cohesive resistance of the material, whereas tensile tests were appropriate to estimate the adhesion at the interface. Moreover, shear tests are strongly influenced by mechanical properties. The purpose of this study was to evaluate the adhesive capacity of the luting material rather than the stress produced during function hence a tensile bond test was performed.

In the present study the samples were tested under standardized conditions using Universal test machine, maximal tensile load of 40 KN at a crosshead speed of 150 mm/min

Cohesive dentin fracture took place on separation with 25% to 40% of the castings for resin cement, which indicates a superior dentin/resin/metal attachment. This mode of failure was never observed with any of the castings cemented with glass ionomer cement.

In the present study cohesive failure of dentin i.e. root fracture occurred in 20–30% of teeth, failure at the dentin-cement interface in 30–40% and cohesive dentinal fracture in 25–40% luted with resin cement whereas with glass ionomer cement most of them failure at the metal cement interface.

Fendi AlShaarani *et al.*,<sup>[20]</sup> also advocated the utilization of grooves in order to improve retention and extension of the cast crown into the groove improved the retention by 100% rather than blocking the groove during prosthesis fabrication.

## Conclusion

From the study, it was finally concluded that the incorporation of horizontal groove on the internal surface of complete cast crown was found to be a satisfactory method compared to preparation modification in tooth to improve the retention in dislodged crowns.

Hence, by utilization of horizontal groove after casting in crowns (especially in short clinical crown conditions) will help us in preventing the dislodgement of crowns, which is more evident when horizontal groove is not placed in short clinical crowns, thereby justifying the Muller De Van statement (Perpetual preservation of what remains is more important than the meticulous replacement of what is lost).

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## Conflicts of interest

There are no conflicts of interest.

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