

Comparative Evaluation of Enhancing Retention of Dislodged Crowns Using Preparation Modifications and Luting Cements: An *In-Vitro* Study

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Abstract:

Background: 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 becomes loose. Providers 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.

To determine whether the addition of horizontal groove in the internal surface of the crown and/or tooth preparation will increase retention of the crowns, without remaking them and achieving better retention with cements.

Materials and Methods: A total of 80 extracted human mandibular molars were taken and standard preparation was done. After the crowns were ready, the groove was made in the internal surface of the crown and on the tooth, which were cemented with glass ionomer cement and resin cement. The tensile force needed to dislodge the crowns and teeth after cementation was found out.

Result: The mean tensile force needed to dislodge the crown and tooth combination was highest for the group in which crown had a groove without any groove on the tooth and cemented using resin cement (252.60N).

Conclusion: It can be concluded from the study that it is best to recement a crown and tooth combination using resin cement where the crown has a groove, and the tooth has no groove.

Key Words: Circumferential horizontal groove, glass ionomer cement, resin cement

Introduction

One of the major requirements of prosthodontics crowns and bridges is to achieve maximum longevity of the restoration with an unbroken surface contact between the restoration and the tooth surface.¹

It was found out that dental cements influence crown retention, but no biocompatible cements can maintain a restoration in place by adhesion alone. The shape of the preparation must place the cement in compression to provide the necessary retention and resistance.² It was showed that changing the surface of tooth preparation by adding vertical grooves, boxes, pin holes increased the surface area and resistance form. It was shown that two vertical grooves placed in the tooth preparation significantly increased the resistance to a rotational dislodgement.³

In this study, cast metal complete crowns without grooves and crowns that had horizontal circumferential grooves placed in their internal aspect were vertically dislodged from extracted human mandibular molar teeth, with and without grooves, having an ideal shoulder preparation. The purpose of this *in-vitro* study was to determine whether adding horizontal groove to the internal surface of the crown and/or tooth preparation would improve retention of a metal complete crown and the recementation strength of their respective restorations upon cementation with conventional and adhesive cements. The null hypothesis was that adding horizontal grooves inside the crown and/or on the tooth surface would not increase crown retention and that there would be no difference in the recementation strength of complete metal crowns luted with different cements.^{3,4}

Materials and Methods

Freshly extracted human mandibular molars, 80 in number were selected. The molars were embedded in standard mild steel cylinders (12 mm diameter, 20 mm length) with self-curing acrylic resin to within 2 mm of the cemento-enamel junction, with the long axis of the roots perpendicular to the horizontal plane. After the resin had completely set, all the specimens were preserved in deionized water until further use.

Standardized full-coverage crown preparation was carried out using an air rotor and a flat end tapered diamond bur mounted on a custom made jig attached to the dental surveyor. Depth orientation was done using 1.5 mm diameter round bur for the

occlusal surface. The preparations were at least 4 mm high. An individual impression of each specimen was recorded with very high viscosity polyvinylsiloxane impression material. After the putty had set, light body polyvinylsiloxane impression material was mixed as per the manufacturer's instructions and placed in the impression tray and also syringed onto the tooth specimen. The prepared specimen was reinserted into the tray and firmly seated. It was held in place for 4-5 min from start of mixing, then removed and inspected.

Impressions were poured in Type IV die stone. A total of 80 dies were poured. The set die was separated from the impressions. 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. The wax patterns were fabricated. The dies were then invested. Casting was performed.

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 1 horizontal circumferential groove was placed free hand on the internal surface of the crown. The groove was 0.5 mm deep and 1.4 mm wide. The groove was placed approximately 3 mm from the cervical margin. Similarly, teeth were taken and 1 horizontal circumferential groove was placed on the tooth with the depth orientation round bur and carbide bur, respectively, 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 after cementation. The castings and the prepared teeth were divided into eight groups ($n = 10$):

- Control: Casting and teeth were unaltered.
- Group 1: Casting had a groove, and the teeth had no groove.
- Group 2: Casting had no groove and teeth had a groove.
- Group 3: Casting, as well as the teeth, had a groove.

The specimens were divided into two groups of 40 specimens each ($40 \times 2 = 80$). The above-mentioned samples were then cemented with the two cements used in this study.

Cement 1: Glass ionomer cement (GIC) (GC FUGI 1).

Cement 2: Resin Cement (Rely X Unicem).

The powder and the liquid of the GIC were mixed by hand on a paper pad using an agate spatula. 1.8 g of powder was mixed with 1.2 ml of the liquid. Both powder and liquid was mixed within 15 s, and the mix was completed within 30 s.

The resin cement is a two-paste clicker system, which allowed equal quantities of base and catalyst to be dispensed for mixing. 2 clicks were used for each sample. The cement was mixed and cemented onto the preparations according to the manufacturer's instruction.

The specimens were then subjected to the tensile loading using a universal testing machine. The values recorded by the testing machine were then compared. A vertical uniaxial tensile load (5000N load cell) was applied to each casting with a constant speed of 1-mm/min until failure occurred. The maximum load at failure was recorded for each specimen. The data were described in mean, standard deviation (SD), and range values. Analysis of Variance (ANOVA) was used for multiple group comparisons followed by Bonferroni test for multiple pairwise comparisons to assess any significant difference between groups. $P = 0.05$, or less was considered statistically significant.

Results

All specimens were randomly divided into eight groups. Each group consisted of 10 specimens.

- Group 1: Control group - Both crown and tooth without groove cemented with GIC cement
- Group 2: Control group - Both crown and tooth without groove cemented with Resin cement
- Group 3: Crown with groove and tooth without groove cemented with GIC
- Group 4: Crown with groove and tooth without groove cemented with Resin cement
- Group 5: Tooth with groove and crown without groove cemented with GIC cement
- Group 6: Tooth without groove and crown with groove cemented with Resin cement
- Group 7: Both crown and tooth with groove cemented with GIC cement
- Group 8: Both crown and tooth with groove cemented with Resin cement.

Mean values and SDs of each group are listed in Table 1 and Graph 1. The highest mean tensile bond strength was obtained for Group 4 (252.60N), and the lowest was obtained for Group 1, which was the control (187.55N). The highest SD was found for Group 7 (9.04), and lowest SD was found for Group 5 (5.47).

In order to compare the means of the groups ANOVA using Statistical Package for Social Scientist at a level of significance 0.05 and at a confidence level of 95%. The results of ANOVA have been listed in Table 2. From the results of the analysis,

Table 1: Mean value, SD, and range (in Newtons) of a different group.

Group	Mean	SD	Range
Group 1	116.85	8.23	102.53-125.62
Group 2	187.55	6.02	178.36-195.31
Group 3	176.43	6.85	163.24-184.21
Group 4	252.60	7.91	238.56-262.56
Group 5	129.49	5.47	118.23-135.67
Group 6	196.81	6.91	186.31-209.26
Group 7	168.10	9.04	153.31-179.31
Group 8	239.22	5.61	229.21-246.32

SD: Standard deviation

it was found that there was a highly significant difference between the groups with respect to the load ($F = 456.656$, $P < 0.001$).

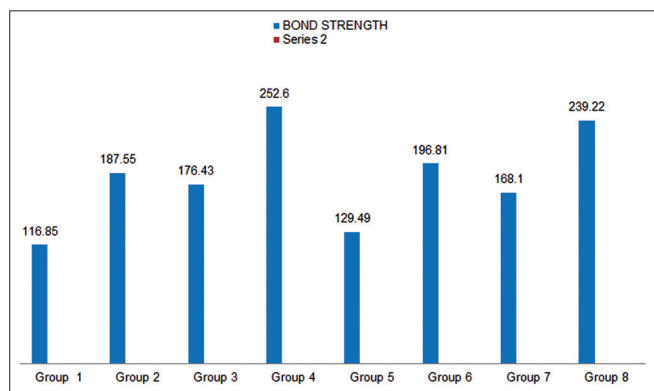
In order to find out among which groups there exists a significant difference, multiple comparisons using Bonferroni test was done. The results of the test are shown in Table 3 and Graph 2.

Discussion

This experiment tested the tensile force required to dislodge a crown from a tooth. The data support the rejection of the null hypothesis that altering the crown and tooth would not increase retention. Since all the teeth were identical, as were all the crowns the results compare the vertical force required to dislodge the crown using the cements.^{5,6} The looser fit was considered to represent most clinical situations where a crown has been dislodged from an ideal preparation. These tests demonstrated a cohesive failure of the cement since cement components were found on both the crown and tooth preparation surfaces.³

Groove was made in the crown for one group, on the tooth for the other, and one group had grooves both in the crown and on the tooth. Control group had crowns and teeth combination without any grooves. These combinations were cemented with GC Fuji 1 cement and Rely X cement and the amount of force required to dislodge was found out.⁷ This tested the tensile force required to dislodge the crown ant teeth combination using a universal testing machine. Grooves on the crowns and tooth were placed approximately in the same positions so as to be opposite each other when cemented together. The theory behind this procedure was that the alignment of the grooves would place some of the cement interface under compression. Studies have been done in the past where they have placed two grooves in the crown and the teeth, but this was not done in the present study because fabricating opposing grooves in the mouth is possible; however, creating two pairs of opposing grooves is difficult.⁸ Clinical experience has shown that most dislodged crowns do not have enough tooth surface area to accommodate two grooves.³

The results show that the mean force required to dislodge the crown from the tooth was highest for Group 4 (252.60N), followed by Group 8 (239.22N), Group 6 (196.81N), Group 2 (187.55N), Group 3 (176.43N), Group 7 (168.10N), Group 5 (129.49N), Group1(116.85N).

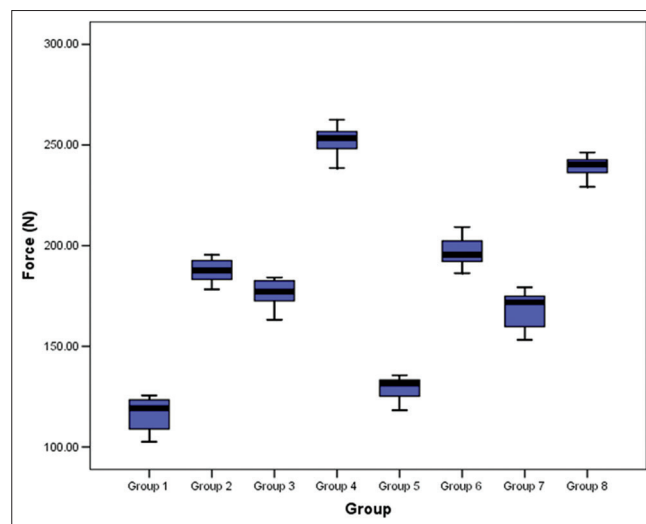


Graph 1: Mean force (N) recorded for different groups.

Table 2: Multiple group comparisons: ANOVA.

Source of variation	df	SS	Mean SS	F	P value
Between groups	7	157189.090	22455.584	456.656	<0.001*
Within groups	72	3540.527	49.174	-	-
Total	79	160729.617	-	-	-

SS: Sum of squares, ANOVA: Analysis of variance



Graph 2: Box plot of tensile bond strength (N).

Table 3: Multiple comparison between the groups: Bonferroni test.

Groups	Mean	SD	SEM	95% CI for mean		Minimum	Maximum
				Lower bound	Upper bound		
Group 1	116.85	8.23	2.60	110.97	122.74	102.53	125.62
Group 2	187.55	6.02	1.90	183.24	191.86	178.36	195.31
Group 3	176.43	6.85	2.17	171.53	181.33	163.24	184.21
Group 4	252.60	7.19	2.27	247.46	257.74	238.56	262.56
Group 5	129.49	5.47	1.73	125.58	133.40	118.23	135.67
Group 6	196.81	6.91	2.19	191.87	201.76	186.31	209.26
Group 7	168.10	9.04	2.86	161.63	174.57	153.31	179.31
Group 8	239.22	5.61	1.77	235.21	243.23	229.21	246.32

SD: Standard deviation, SEM: Standard error mean

Group 4 required the highest tensile force. This group had a groove on the crown and tooth did not have any groove, and the combination was cemented with resin cement. This shows that placing groove on the internal surface of the crown and recementing it with resin cement will be most advantageous. This value was almost comparable to the value obtained for Group 8 where both crown and tooth had grooves and the combination was cemented with resin cement. This shows that a single groove in the crown is as effective in increasing retention as single opposing grooves both in the crown and tooth and that grooving the internal surface of the crown may be the most efficient and easiest method of obtaining additional retention.³

Group 6 had a groove on the tooth whereas the crown had no groove and this combination was cemented with resin cement. This shows that placing groove on the surface of the tooth without placing any groove in the crown did not give the desired result. This should not be considered as an option when recementation of dislodged crowns with preparation modifications is concerned. Either groove should be placed on both tooth or crown or better option is to place only in the crown.

Group 2 is the control group where neither the crown nor the tooth had any groove, and the combination was cemented with resin cement. This value was almost comparable to the value obtained in the case of Group 6 where the tooth had groove and crown had no groove and the combination was cemented with resin cement. This shows that making preparation modifications does increase the tensile force required to dislodge the crown from the tooth but making groove on the tooth alone is of not much importance unless groove had also been made in the crown.

Furthermore, when we compare the values of Group 2 with Group 3 where the crown had groove without any groove on the tooth cemented with GIC cement, the values were more for Group 2. This shows that recementing the combination without any modifications with resin cement is any day better than making preparation modifications and recementing the combination with GIC cement. Hence, this proves that dislodged crowns should be recemented with Resin cement rather than GIC cement.

Although the present study showed that preparation modifications add to the recementation strength of the dislodged crowns, it should also be noted that the ideal tooth preparation described in this study is not necessarily observed clinically.⁹ Shorter clinical preparations, poor tooth foundation, and preparations with convergence angles of 20° or greater, shift the cement interface from compression to shear, resulting in a greater possibility of failure of the cement interface through cohesive fracture. Furthermore, clinically, many other factors such as bruxism, types of food masticated, the amount of saliva

in the mouth, and number of teeth remaining may be involved in dislodging a crown.¹⁰ Follow-up studies changing the height of the axial walls and/or the total occlusal convergence of the preparation could confirm the benefit of adding grooves.³

Therefore, within the limitations of this study, it can be concluded that making preparation modification for dislodged crowns and recementing them improves the force with which they are dislodged. It is best to make a single groove in the internal surface of the crown without making any groove on the external surface of the tooth and recement it with the help of resin cement.

Conclusion

Within the limitations of this study, the following conclusions were made:

1. The mean tensile bond strength values of crowns that were recemented with preparation modifications were higher than those recemented without any preparation modifications.
2. The mean tensile bond strength value of the combination in which the crowns had groove and tooth had no groove was higher than any other combination group.
3. The mean tensile bond strength value of the combination in which both crown and the tooth had groove had values, which came next among the combination group.
4. The mean tensile bond strength value of the combination in which the tooth had groove, and the crown had no groove had least values among the combination groups.
5. The mean tensile bond strength value of the combination was always higher when Resin cement was used as the luting agent to recement the dislodged crown than when GIC was used as the luting cement to recement it.

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