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Research Article

COMPARATIVE EVALUATION OF RETENTION OF NICKEL-CHROMIUM CROWN BY ADDITION OF ONE AND TWO HORIZONTAL GROOVES ON THE INTERNAL SURFACE OF CROWN: AN IN VITRO STUDY

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A B S T R A C T

Statement of Problem. The best treatment for a dislodged crown is not clear.

Purpose. This study was designed to evaluate the increase in the retention form of the fixed prosthesis after placement of one and two horizontal grooves on the internal surface of the crown.

Materials and Method: 90 Freshly extracted sound, non-carious, non-restored human maxillary first premolar teeth were used and standard tooth preparation was done. Nickel Chromium crowns were fabricated, one and two horizontal circumferential grooves were placed on the internal surface of crown. All specimens were cemented with Resin modified glass ionomer cement and then subjected to a retention testing on universal testing machine until they were dislodged. The data was subjected to one way ANOVA test followed by Least Significant Difference (LSD) post hoc test.

Results: The results of the study showed that the mean retention value of Nickel Chromium crowns with two horizontal grooves was highest amongst all the three groups. Whereas the crowns luted with Resin modified glass ionomer cement with unaltered crowns showed the least mean retentive value. This clearly inferred that mean retention value of Nickel Chromium crowns with one and two horizontal grooves on the internal surface of crown was found out to be higher than that of unaltered crown. (p<0.05)

Conclusion: The retention of Nickel Chromium crowns significantly increased when one and two horizontal grooves were placed on the internal surface of crown luted with resin modified glass ionomer cement. There was no statistically significant difference between the mean retention value of crown with one horizontal groove and two horizontal grooves. The incorporation of horizontal groove on the internal surface of complete cast crown was found to be a satisfactory method to improve the retention.

INTRODUCTION

For the long term and harmonious accommodation of restorative material, teeth require preparations which are based on Biological, Mechanical and Esthetic principles.[1]

In developing countries like India, complete cast crowns due to their longevity and resin modified glass ionomer cement due to their lesser solubility and excellent mechanical properties enjoy the popularity of being one of the most popular clinician's choice.

When the occlusion is not 3-dimensionally stable, a combination of compression as well as tensile/shear influences act on the restorative material [2] which along with other factors like bruxism may lead to dislodgment of a crown. In such cases, there arises a need for added retention to the prosthesis which can be achieved by either surface modification on the external surface of tooth as well as by modifications on the internal surface of crowns [3].

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.[2]

Various investigators have worked on this aspect, but, there is no uniform consensus regarding the effect of supplementing retention through crown preparation modification on retention of nickel chromium crown on extracted human maxillary first premolar luted with Resin modified glass ionomer cement. Hence, this study was done to evaluate the increase in the retention form of the fixed prosthesis after placement of one and two horizontal grooves on the internal surface of the crown. The null hypothesis was that addition of horizontal grooves would not increase the retention.

MATERIALS AND METHOD

90 Freshly extracted sound, non-carious, non-restored human maxillary first premolar teeth extracted for orthodontic purpose were collected, cleaned and disinfected with 5% sodium hypochlorite solution.

From the collected bulk, teeth with closely matching anatomic crown length and other dimensions measured by digital vernier calliper were stored in distilled water till mounting. These teeth were notched with a carborundum disk to resist dislodgement and then mounted on acrylic blocks (DPI-RR, Dental products of India Ltd., Mumbai) of dimension 1 × 1inch each. The mounted samples were then stored in distilled water until further use.

For standardization protocol, an airotor handpiece (Pana air NSK, Japan) was mounted on the dental surveyor (William's) with the help of test tube holder to keep the diamond point parallel to the long axis of the specimen. The tooth preparations were done under copious water irrigation.

Using straight flat diamond point (SF-12, Dia-Burs, Mani Inc. Japan) guiding grooves were placed for occlusal reduction. The occlusal surface reduction was done with 1.5 mm on the functional cusp and 1 mm on the non-functional cusp using dumbbell shaped diamond point (EX-11, Dia-Burs, Mani Inc. Japan) of the teeth having cuspal morphology

Axial reduction was done using a tapered round ended diamond point (TR-26, Dia-Burs, Mani Inc. Japan). Constant taper of 6^0 for the preparations was obtained. A uniform chamfer finish line was obtained. A bevel of 45^0 was given at the axio-occlusal line angle by the straight flat diamond point (SF-12, Dia-Burs, Mani Inc. Japan) to keep the width of the bevel relatively constant at 0.5mm. The preparations were finished using extra fine grit tapered round ended diamond point (TR-13EF, Dia-Burs, Mani Inc. Japan). All the prepared teeth were kept at least 4mm 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. Tray adhesive (CAULK Tray adhesive, Dentsply, Germany) was applied on the inner surface of tray. Impressions of the prepared teeth were made with polyvinyl siloxane putty impression material (Aquasil soft putty/Regular set, Dentsply, Germany) using two-stage putty-wash technique. After the putty had set, the spacer was removed to make way for the light body impression material. The putty laden custom tray having light body was again placed over the specimen. After final setting of 5 minutes of light body, impressions were removed and poured in type V gypsum ie Die stone (Ultrarock, Kalabhai, Mumbai) and were allowed to set as per manufacturer's recommendation.

All 90 dies were retrieved and checked for bubbles, voids or any defects. Defective dies were discarded and impression was again poured.

After the application of Die hardner (Euro die hardner, Kerr restoratives) which was allowed to set for 2 minutes, two coats of die spacer (Durolan DFS diamon) were applied to dies, 0.5mm above the prepared margin of the tooth. Die lubricant (Die lube, Dentsply, Germany) was applied over the die.

The Wax patterns were fabricated and casting was done using Nickel-Chromium alloy, (CB 80, Dentsply India) in induction casting machine (LC-cast, Confident, India). Internal surface of all castings were evaluated under magnification for any casting defects.

The internal surfaces of all crowns were sandblasted using sandblasting unit (SANTER LABO-16, Confident, India) with the 110µ aluminium oxide particles (Siladent) for 10 seconds at 20 kg/cm^2.

Grouping of the samples

90 Nickel-Chromium complete cast metal crowns were randomly divided into 3 groups of 30 samples each.

Group I: - The control group being the unaltered crown.
Group II: - One Horizontal groove around the circumference of the internal surface of crown.
Group III: - Two Horizontal grooves around the circumference of the internal surface of crown.

Horizontal circumferential groove / grooves were placed (Fig.1) for Group II and III whereas Group I acted as a control group. (Fig.2) For Group II, One horizontal circumferential groove was placed free hand on the internal surface of all 30 crowns by inverted cone bur (#37, SS White RA-36.USA) using Laboratory Micromotor and contrangle handpiece (Marathon - 3+, Marathon, Korea).

Figure 1 Placing one and two horizontal grooves on the internal surface of the crown

Figure 2 Unaltered Crown

Figure 3 Crown with single groove

The groove placed on the internal surface of crown was approximately 3 mm from the cervical margin and 0.5 mm in depth and 1.4 mm in width. (Fig.3)

Figure 4 Crown with two grooves

In Group III, Two horizontal circumferential grooves were placed. The first horizontal groove was placed 3 mm from the cervical margin and 0.5 mm in depth whereas second groove of 0.5 mm depth and 1.4 mm in width was placed parallel to first groove and 2 millimetres apart. (Fig. 4) Crowns of all these 3 groups were luted with Type I Resin Modified Glass Ionomer Cement (GC Fuji Cem, Japan) for respective specimen which is a two paste clicker system, as it allowed equal quantities of base and catalyst to be dispensed for mixing.

The cement was mixed according to manufacturer's instructions and painted on the axial surface of the internal surface of the crown. The crown was then seated over the tooth specimen before 30 seconds. Dead load of 5 kg was applied to the occlusal surface of each specimen. The load was maintained for 5 minutes. The excess cement was removed with a curette.

The same procedure was done for cementation of all crowns to respective prepared specimens. Then specimens were stored for 24hrs at 37^0C and 100% relative humidity. All specimens were subjected to 1000 cycles of thermocycling in Thermal Shock Tester (5^0C: LG Model: 051SA; 55^0C: Mahavir, India).

The retention testing of all samples were performed on the computerized software based Universal testing machine (Instron, Model no. 3345, and UK). At the 0.5 mm/min. cross-head speeds, a vertical tensional force was applied on the crowns consistently [4]. The maximal tensile force used to separate the crown was recorded in Newton. (Fig. 5)

Figure 5 Dislodged crown from tooth

RESULTS

The results of the study showed that the mean retention value for Group I (Control) was 211.78 N, for Group II 327.87 N, and for Group III 360.04 N (Graph 1). The mean retention value of Nickel Chromium crowns with two horizontal grooves (Group III) was highest amongst all the three groups. Whereas the crowns luted with Resin Modified Glass Ionomer Cement with unaltered crowns (Group I) showed the least mean retentive value. This clearly inferred that mean retention value of Nickel Chromium crowns with one and two horizontal grooves on the internal surface of crown ie Group II and III was found out to be higher than that of Group I (Control Group).

Mean and standard deviation **Table 1**

	N	Mean	Std. Deviation	Std. Error
Group I	30	211.7883	84.87414	15.49583
Group II	30	327.8767	18.21061	3.32479
Group III	30	360.0453	184.82358	33.74401
Total	90	299.9034	132.98938	14.01831

Statistical analysis was done with Statistical Package for the Social Sciences, One way Analysis Of Variance (ANOVA) test (Table 2) followed by Least Significant Difference (LSD) post hoc test (Table 3) was used for pair wise comparison between different groups.

ANOVA test result **Table 2**

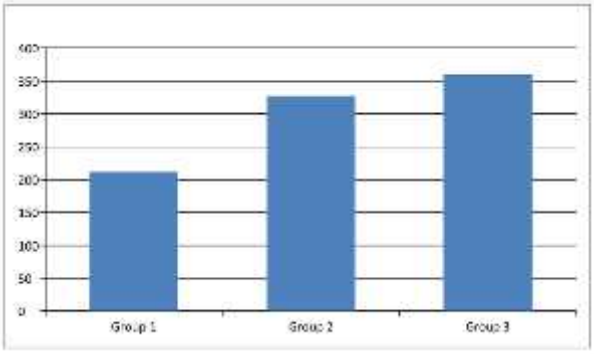
	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	364914.623	2	182457.312	13.128	0.00001041
Within Groups	1209155.045	87	13898.334		
Total	1574069.668	89			

Multiple Comparisons LSD test Result **Table 3**

(I) Groups	(J) Groups	Mean Difference (I-J)	Std. Error	p-value
Group I	Group II	-116.08833*	30.43938	0.0002552
Group I	Group III	-148.25700*	30.43938	0.000004942
Group II	Group III	-32.16867	30.43938	0.294

*. The mean difference is significant at the 0.05 level.

Mean retention value of Group I, II and III



X- axis = Group I, II, III Y-axis:- values in Newton

DISCUSSION

The results of the present study showed that the mean retention value for Group I (Control) 211.78N, for Group II 327.87N, and 360.04N for Group III. The results stated that

incorporation of horizontal grooves within the crowns significantly increased the retention of Nickel Chromium crowns. Hence, the Null Hypothesis was rejected for Group I-II and Group I-III but it got accepted for Group II-III. The mean retention values of crowns with one horizontal groove (Group II) and two horizontal grooves (Group III) were found out to be significantly higher than that of Group I ($p<0.05$) in which crowns were luted with Resin Modified Glass Ionomer Cement without incorporation of horizontal groove. But, there was no statistically significant difference between the mean retention value of Group II and Group III.

Retention form is the feature of a tooth preparation that resists dislodgment of a crown in a vertical direction or along the path of placement (GPT 8). "Lack of retention" is one of the most common causes of failure for fixed dental prosthesis. Retention is a key factor in the success of a fixed prosthesis and it is determined by following factors: Magnitude of the dislodging forces, Geometry of the tooth preparation which includes taper, surface area, stress concentration (e.g., rounding the internal line angles), type of preparation, roughness of the fitting surface of the restoration, type of luting agent used.[1]

To provide retention and resistance form to a non resistant preparation, the preparation done can be modified by crown lengthening, shoulder preparation, proximal groove, proximal box or occlusal isthmus, and pins or posts. Generally, internal features such as groove, box form, and pin hole are interchangeable and can be substituted for an axial wall or for each other.

It is stated that adding axial grooves or boxes to a preparation does not markedly affect its retention because the surface area is not increased significantly. However, on the other hand, the addition of a groove aids in increased retention by limiting the paths of withdrawal.[5]

Modification of internal surface of crown may increase the retention. Chan KC, Hormati AA, *et al.* (1981) [6] had perceived this notion. They proposed that retentive grooves can either be given on the tooth surface or on the internal surface of the complete cast crown. Their findings suggested cement keys to be an effective mean of increasing the retention of complete cast crown in preparation of extracted teeth.

Also, Witwer DJ, Storey RJ *et al.* (1986) [7] evaluated the retention of cast prostheses with retentive grooves placed only on the internal surface of the complete cast crown. They tested the ability of different luting agents (zinc phosphate and zinc polycarboxylate cements) affecting the retention.

These results were in accordance with Chan KC *et al.* (1981) [6], O'Kray H, Marshall TS *et al.* (2012) [2],Amarnath GS *et al.* (2015) [3] 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 groove on the internal surface of complete cast crown would place some part of the cement interface under the state of compression.[2, 3] As most of the luting agents are weak in shear and tensile forces, hence cement in state of compression would help to increase the retention.

However, the findings of the present study were not in agreement with the findings of Witwer DJ *et al.* [7] where they concluded that neither a single groove placed in the tooth nor in the crown was effective in increasing the retention. Chan KC *et al.* [6] emphasized that creation of cement keys acts as an effective means of increasing the retention of complete cast crowns.

In the present study, Grooves were given on the internal surface of crown instead of tooth because it has been seen that there is an increase in the retention of crown when groove was placed on the internal surface of crown than when placed on the tooth surface.[6, 8]

The result of this study showed that addition of one and two horizontal grooves on the internal surface of Nickel Chromium crown significantly increased the retention without further altering the tooth surface making recementation procedure easy for the dentist and long term beneficial for the patient.

The limitations of this study, as this being an in-vitro study could not replicate the conditions present in the oral environment. To mimic the oral conditions, thermocycling of the samples were carried out; but still the effect of saliva, moisture, intraoral temperature and humidity cannot be underestimated. The dislodging forces to which a fixed crown is subjected in the oral cavity are multidirectional may it be vertical, lateral or oblique forces but on the other hand the dislodging force exerted by the Universal Testing Machine is unidirectional and considerably higher than maximal physiologic forces acting on the teeth intraorally. So, a direct comparison between dislodging forces encountered in the oral cavity and those exerted by the universal testing machine is ambiguous. This study was performed only on the extracted human maxillary first premolars; consideration should be given for further studies on Incisors, second Premolar, and Molars and also in mandibular counterparts. Horizontal groove with 0.5 mm depth was placed on the internal surface of Nickel Chromium 3mm away from the cervical margin, whereas effect of horizontal groove at different location and depth should also be evaluated. Luting agent used for this study was only Resin Modified Glass Ionomer Cement, other luting agents should be considered. Metal used for the fabrication of crown was Nickel Chromium only, while other metal like Cobalt-Chromium and Gold should be considered.

CONCLUSION

Within the limitations of the study, the following conclusions were drawn-

The retention of Nickel Chromium crowns significantly increased when one and two horizontal grooves were placed on the internal surface of crown luted with resin modified glass ionomer cement. There was no statistically significant difference between the mean retention value of crown with one and two horizontal grooves. The incorporation of horizontal groove on the internal surface of complete cast crown was found to be a satisfactory method to improve the retention, however further research is required with different luting agents and different crown materials.

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