‘Evaluation and Comparison of The Retention of Full Cast Metal Crowns Cemented on Extracted Natural Teeth with And Without Auxiliary Retentive Features - An In Vitro Study’

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Abstract

To evaluate and compare of the retention of full cast metal crowns cemented on extracted natural teeth with and without auxiliary retentive features.

Materials and Method: 30 extracted non carious maxillary 1st premolars were selected and were prepared to receive full cast metal crowns. These prepared samples were randomly grouped into three groups Group A, Group B and Group C; with 10 samples each. Group A consisted teeth that were prepared conventionally. In Group B, two auxiliary grooves that run parallel to each other were prepared on mesial and distal proximal surfaces. In group C, two auxiliary boxes were placed in the mesial and distal proximal surfaces. An elastomeric impression material was made and poured with Type IV gypsum material. The wax patterns for full metal cast crown were carved on die and were invested and casted in Ni-Cr dental alloy using induction casting machine. All thirty samples were luted using Type I glass ionomer cement using firm finger pressure. The samples were tested for retention after 24 hours with the help of a universal testing machine. The force of dislodgement for all the thirty samples were recorded in MPa.

Results: The results showed that there was a statistically significant increase in the retention of the complete cast crowns on teeth with incorporation of retentive features in the tooth preparation compared to the conventional preparations. The increases in retention obtained by the incorporation of proximal boxes were more significant compared to incorporation of proximal grooves and the conventional preparations.

Conclusion: Complete cast crowns on teeth with auxiliary retentive features produced significant increase in retention of complete cast crowns.

Key words: Extracted non carious maxillary 1st premolars, Tooth preparation, Proximal grooves and boxes, Full cast metal crowns, Luting cement.

Introduction

Prosthodontics is a branch of dentistry which is related to the rehabilitation of any of the oral and facial structures to provide function, comfort and prevent any further degradation of health while maintaining the natural appearance and giving a psychological relaxation.[1] Healthy natural dentition plays a vital role in mastication, speech and esthetics. When enamel or dentin is lost as a result of caries, trauma or wear, restorative

materials must be used to re-establish the normal form and function.[1-3]

Fixed partial denture is one of the most commonly used treatment modalities for partial edentulism in which the replacement and/or restoration of teeth are done using artificial substitutes that are not readily removable from the mouth.[4]

Tooth preparation should follow certain mechanical, biological and esthetic principles. However, the availability of adhesive luting cements which bond the restoration to the tooth surface chemico-mechanically offers the possibility of increased crown retention independent of preparation geometry.[5,6] Loss of retention is most commonly attributed to reduced crown height or lack of tooth structure which have always been a challenge to the dental professionals.

Whenever maximum retention and resistance are needed on short clinical crowns or when high displacement forces are anticipated, such as for the retainer of long-span FPD, then additional auxiliary retentive features should be included like grooves and boxes. Retention form of a tooth preparation prevents the removal of the restoration along the path of insertion whereas resistance form prevents dislodgement of the restoration under occlusal forces.[7, 8] The mechanical properties of the cement can influence stress distribution within the interposed cement layer, the bonding efficacy of cement to both surfaces and durability of cement, including the long term resistance to mechanical deterioration[9].

The findings of different authors regarding enhancement of retention by provision of retentive features are at variance. A few studies have been done on molar teeth. This study for retention using premolar teeth is not frequently observed in literatures so the purpose of this in vitro study was to evaluate and compare retention of full cast metal crowns cemented on extracted natural teeth with and without auxiliary retentive features.

Materials and Method

Non carious maxillary 1st premolar teeth extracted for orthodontic treatment were selected and were treated with hydrogen peroxide and were stored in normal saline (0.9%). Thirty samples with approximately similar dimensions were selected for this study and mounted onto auto polymerizing acrylic resin block 2 mm (DPI India) (Fig. 1).

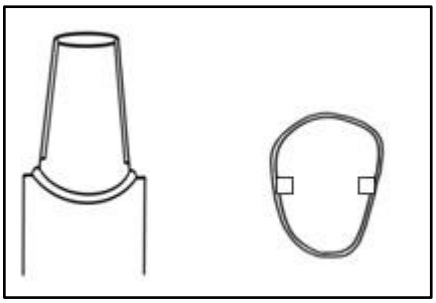

Fig.1

A high speed airotor hand piece (1,00,000 to 2,00,000 rpm) was attached to the vertical arm of a dental surveyor (Dentalfarm, Italy) using lockable joint (Fig.2).

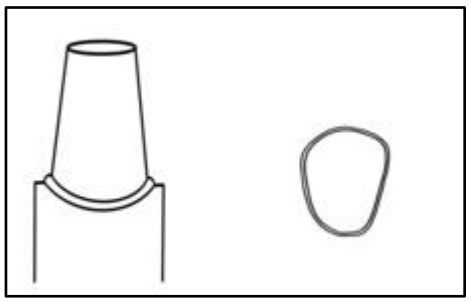

Fig.2

Tooth preparation was carried out to achieve uniform chamfer margin of 0.75 mm and overall taper of 6°. Approximately 1mm to 1.5 mm of axial tooth structure was removed by preparation. Gingival finish line of each tooth was maintained 0.5 mm above the cemento-enamel junction. The occlusal surfaces of the samples were sectioned flat with the help of a small wheel diameter bur. The teeth were prepared to a constant height of 3.5 mm as measured at the mid buccal surface. The prepared surfaces were refined using SF 102R diamond bur.

These prepared samples were randomly grouped into three groups-Group A, Group B and Group C with 10 samples each (Fig.3).

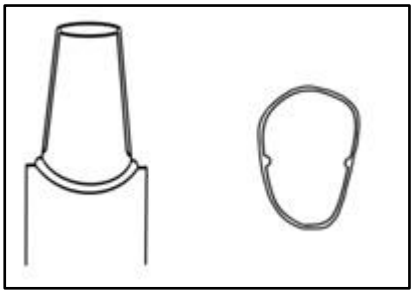

Fig.3

Each group consisted of 10 samples. Group A consisted of teeth that were prepared conventionally served as the control group. In Group B, two auxiliary grooves that run parallel to each other were placed on mesial and distal proximal surfaces. For group C, two auxiliary boxes were placed in the mesial and distal proximal surfaces.

Depth of each groove equaled to half the diameter of the tapered carbide fissure bur of 1mm width. The proximal grooves were terminated 0.5 mm above the chamfer finish line and both the grooves were prepared parallel to each other. Depth of the auxiliary box 0.5 mm and its width was 2 mm. The gingival wall of the box was terminated 0.5 mm above the chamfer finish line. Both mesial and distal boxes were placed parallel to each other.

Impressions for each group of the prepared teeth were made using multiple mix single stage technique with polyvinylsiloxane (PVS) impression material (Flexeed, GC, Japan) following manufacturer's instructions. The impressions were removed and checked for the defects. After half an hour impression were poured using Type IV gypsum material (Shruti, Ultra Real). The gypsum was mixed in vacuum mixer (Whip mix, USA) according to manufacturer's instructions and poured to obtain master dies for the study purpose.

After die examination, die hardener (Hartebad, Renfert, Germany) was applied followed by one coat of die spacer (Pico-Fit, Germany). Die lubricant (isolit) was painted on the master die. Wax pattern (Inlay wax Type II, Crowax, Renfert, Germany) for full metal cast crown was carved on the die using PKT wax instrument (Fig.4) (GDC, India).

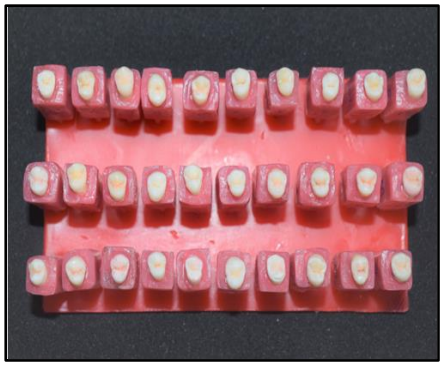

Fig.4

The wax patterns were sprued (Renert, Germany) and sprayed with debubblizer solution (Aurofilm, Bego, Germany). Then the investment material was added to the casting ring under mechanical vibration. The invested casting ring was set aside for 1 hour to allow complete setting of investing material. The burnout procedure was then carried out in a burnout furnace at 950°C (Miditherm, Bego, Germany)

After the burnout procedure, the casting was carried out in an electrical induction casting machine (Fornax, Bego, Germany). After the casting procedure, the metal crowns were retrieved from the investment. A sandblasting unit was used to remove all residual investment materials using 80µ Al_2O_3 particles and then metal trimming and finishing were performed using tungsten carbide burs and finishing stones at low speed. The metal crowns were then polished using metal polishing cakes in a polishing unit. The fit of the castings was again verified on the preparation. All the castings were cleansed in the ultrasonic cleaning unit for 15 minutes.

All thirty samples were luted using Type I glass ionomer cement (GC, Gold label, Japan). The luting agent was manipulated according manufacture's recommendation. 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 were mixed, and the mix was completed within 30 sec. Each casting was then filled with sufficient cement to evenly cover the inner surface, seated on the tooth using firm finger pressure. These all cementations were done on the same day by same operator. Care was taken to see that excess cement was flown all around. Using explorer excess cement was carefully removed. Marginal gap was seen before and after cementation to verify complete seating of the casting. The samples were then stored for 24 hours in normal saline at 37 degree at 100% humidity before mechanical testing. The samples were subjected to a vertical dislodgment force until failure on a universal testing machine (Lloyds, UK). Atensile load of 500 KN at cross head speed of 0.5 mm per minute was applied and the castings were pulled along the apico-coronal axis of each tooth using a "J" hook attached to the upper member of the testing machine (Fig.5).

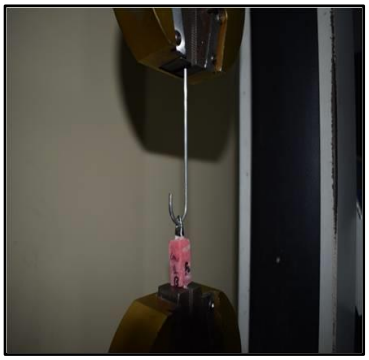

Fig.5

The force of dislodgement for all the thirty samples were recorded in Newton (N). Data were collected and subjected to statistical analysis.

Statistical analysis and Results:

The data was analyzed using Microsoft excel 2007 & SPSS version 20 and using descriptive, one-way ANOVA with Schiff's Post hoc test. (Table 1, Table 2, Table 3) The tensile bond strength (MPa) for Group A, Group B and Group C using ANONA were 5.50 MPa $\pm$ 0.611 MPa, 8.80 MPa $\pm$ 0.566 MPa and 9.95 MPa $\pm$ 0.825 MPa respectively. The results showed that there was a statistically significant increase in the retention of the complete cast crowns on teeth with incorporation of retentive features in the tooth preparation compared to the conventional preparations. The increases in retention obtained by the incorporation of proximal boxes were more significant compared to incorporation of proximal grooves and the conventional preparations.

Discussion

Fixed partial denture is most common treatment modality for the partially edentulous conditions. A steadily increasing demand for restorations of edentulous regions with fixed partial dentures has directed attention to the effectiveness of retention of fixed partial denture retainer on abutment teeth.[10, 11] Management and maintenance of various factors are important for a fixed partial denture to serve successfully. These factors include careful analyzation from the initial patient history taking, through the treatment planning phase and following mechanical and biological principles during treatment procedures.[3,4]

In clinical practice, we often come across teeth with clinical crown height less than that suited ideally for complete coverage restoration, more so if the crown has to serve as bridge retainer. Crown lengthening procedures are considered for increasing the clinical height of the tooth for enhancing the retention of the retainer. A feasible alternative in such a situation is the incorporation of various auxiliary retentive features such as pins, grooves or boxes in the preparation design.[1-5, 9, 11, 12]

One of the most important features for providing adequate bulk of metal and strength to restoration is occlusal clearance. For all metal crowns functional cusp reduction of 1.5 mm and nonfunctional cusp reduction of 1.0 mm are enough. Also, functional cusp bevel given on lingual inclines of maxillary palatal cusps and the buccal inclines of maxillary premolar buccal cusps provide space for an adequate bulk of metal in an area of heavy occlusal contact.[13,14] An axial reduction plays an important role in securing space for adequate thickness of restorative material. Inadequate axial reduction will result in over contoured restorations.[15]

However, in certain clinical situations like tooth with reduced height, crowns cannot depend entirely on geometric form of the tooth preparation for retention. In such cases, modifications of tooth preparations with proximal grooves and boxes have been advocated as auxiliary retentive measures. **Potts RG et al** [14] concluded in their study that addition of grooves provided small increase in

retention value but marked increase in resistance value. They also stated incorporation of boxes will improve the retention of the complete cast crowns. The increased retention may be attributed to the fact that lateral walls of the boxes will help tensofrictional resistance and will limit the freedom of displacement. These results were confirmed in studies by **Kishimoto et al** [16] and **Durey KA et al** [17] on resin bonded bridges. **Proussaefs et al** [18] concluded that placing auxiliary retentive features such as grooves and boxes into a compromised tooth preparation (2.5 mm occlusocervical dimension and 20-degree TOC) was not effective when these retentive features possessed the same 20-degree TOC as the prepared axial walls.

When there is increased Total Angle of Occlusal Convergence, multiple path of insertion will be present which will reduce the retention. Placement of auxiliary grooves and boxes in such situations will enhance retention by limiting the path of insertion to a single direction.[12]

Resistance to lateral forces commonly is the determining factor in a crown's resistance to dislodgment. Horizontal components to masticatory cycles and par functional habits direct forces on single crowns that were faciolingual in character. Therefore, consideration should be given to the most appropriate location for auxiliary retentive features. The basic requirement of the grooves and boxes are that the groove should be parallel to the path of insertion.

A major advancement in the current practice of dentistry is the restoration of teeth with tooth colored, adhesive materials. The success and longevity of a dental restoration depends on the sealing of the cavity walls as well as the retention to the tooth surface.

According to **Marchiori M et al** [19] the self-adhesive resin cements and higher preparation height improved crown retention. Even though conventional glass ionomer cement has been plagued by several negative characteristics like, Prolonged setting time that restricts finishing and polishing for approximately 24 hours, sensitivity to moisture during initial hardening, dehydration, rough surface texture, opaqueness, low fracture toughness, and poor wear resistance, it was used in present study because unmodified glass ionomer cement has the maximum use in daily clinical practice.

The present study demonstrated that a clinically compromised complete coverage tooth preparation including reduced occlusocervical dimension, increased Total angle of Occlusal convergence (TOC) the placement of proximal grooves and a reduced occlusocervical to buccolingual dimension ratio offered greater retention with proximal grooves and boxes along with the adhesive cement.

An attempt has been made in this study to evaluate the effect of auxiliary retentive features on retention on cast crowns.

Within the limitations of the present study it was inferred that whenever the principles of parallelism, length and surface area in a tooth are compromised in the clinical situation incorporation of auxiliary retentive grooves and boxes helps

in improving the retention of complete coverage of the cast restorations.

The limitations of present study are that it was not performed under any condition to simulate clinical situation and the forces used to evaluate tensile bond strength was much higher than forces acting intraorally.

Conclusions

Based on the analysis of the results obtained and within the limitations of the study, the following conclusions were drawn:

1) Cementations of complete cast crowns on extracted maxillary 1st premolar teeth with auxiliary retentive features produced a significant increase in retention.

2) Incorporation of proximal groove on the mesial and distal side of the natural tooth produced an increased retention compared to conventional tooth preparation.

3) Incorporation of proximal boxes (mesial and distal) in natural tooth produced the highest retention of complete cast crowns.

4) Among the auxiliary retentive features, incorporation of proximal boxes produced more retention compared to incorporation of proximal grooves and conventional tooth preparation respectively.

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