

Influence of preparation height and luting agent type on crown retention in molars

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Abstract

Aim: Mechanical characteristics of the preparation along with luting agent are significant elements on the maintenance of fixed prostheses. This study aimed at assessing the retention of metal complete crowns luted with two different luting agents under different preparation height. **Methods:** Forty human third molars were selected and prepared to receive total crowns, and were randomly divided in 4 groups: (1) 5-mm preparation height (PH) and RelyX U100 self-adhesive resin cement (SA); (2) 5-mm PH and zinc phosphate (ZP); (3) 3-mm PH and SA; and (4) 3-mm PH and ZP. Crowns were cast in nickel-chromium alloy. The tensile strength was tested in a universal testing machine. **Results:** Mean tensile strength values to crown displacement (kgf) and standard deviation were 39.6 (13.0) for group 1; 16.9 (8.1) for group 2; 32.2 (7.9) for group 3; and 10.6 (3.2) for group 4. Overall, the crowns cemented with SA presented significantly higher mean tensile strength values than ZP, and the 5-mm PH presented significantly higher mean tensile strength values than 3-mm PH. **Conclusions:** The self-adhesive resin cement and higher preparation height improved crown retention.

Keywords: crown retention, luting agents, preparation design.

Introduction

The stabilizing properties of abutments used in cemented complete coverage restorations have been ascribed to retention and resistance form¹⁻³. Geometric configuration of the prepared tooth is essential to promote retention between axial walls of preparation and the prosthetic restoration⁴. The retention shape obtained by tooth preparation must avoid dislocation of the restoration along its insertion axis, acting against tensile forces⁵. Reduction of convergence angle, higher axial surface and minimal occlusal reduction contribute to increase the retentive capability of the prepared tooth⁶⁻⁸.

Several types of luting agents are available and the choice for a material depends of various factors. The retention of most luting agents is based on mechanical imbrications in the irregularities of tooth-restoration interface⁹⁻¹⁰. Zinc phosphate cement is still the most used for crown luting due to its low cost, easy of handling and good mechanical properties¹¹⁻¹³. However, it has some negative properties namely solubility in oral environment and absence of adhesive bonding¹⁴.

The resin cements has significant role in increasing crown retention by promoting an adhesive bonding between tooth and restoration, which has increased the use of these luting agents¹⁵. Nevertheless, the use of these materials requires

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several steps, mainly for treatment of dental substrate, which make them technically sensitive¹⁶. Self-adhesive resin cements have been recently introduced on the market. The goal of these luting agents is to combine the easiness of use offered by zinc phosphate cements (they do not demand pretreatment steps) with the favorable mechanical properties, esthetics and adequate adhesion to dental structure of conventional resin cements^{17,18}.

The aim of this study was evaluate the influence of preparation height (3- or 5-mm) and type of luting agent (zinc phosphate or self-adhesive resin cement) on the retention of metal complete crowns on molars.

Material and methods

The study was approved by the Research Ethics Committee of Uningá (Protocol 0089/08). Forty sound human third molars with similar shapes and dimensions, which had been freshly extracted due to orthodontic or periodontal reasons, were used in this study. The selected teeth were scaled, cleaned for debris and stored in saline, which was constantly renewed.

Specimen preparation

The roots were centrally inserted into PVC cylinders (25-mm height x 20-mm internal diameter; Tigre, Joinville, SC, Brazil) containing self-curing acrylic resin (Jet; Clássico Artigos Odontológicos Ltda., São Paulo, SP, Brazil). The acrylic resin was maintained 2 mm below to the cemento-enamel junction^{12,19}. One horizontal perforation was made in the root equidistant from the cemento-enamel junction and tooth apex, enabling the passing of a rectangular orthodontic wire (Dental Morelli Ltda., Sorocaba, SP, Brazil) to endure that teeth were not removed from the acrylic resin during the tensile test.

Preparation was standardized by using a mechanical lathe, according to previous studies²⁰⁻²¹. Tooth reduction was initiated by positioning the cutting instrument at the cemento-enamel junction and then moving it along the axial wall in a cervical-occlusal direction, under constant cooling. Following axial reduction, the external portion of the root was reduced to standardize the cervical area (Figure 1). Tapered-shaped preparations had the following characteristics: 6.5-mm upper diameter, 16 degree of convergence and the cervical finish line was in straight-shoulder shape. Finishing was made at 45 degree angle on the edge formed by the axial and occlusal walls, where an approximately 1-mm-wide groove was made all around the preparation using a cylindrical diamond bur (#1090; KG Sorensen, Barueri, SP, Brazil) in a handpiece under water cooling. The diamond bur was used in almost the whole area of preparation, simulating the clinical condition.

The teeth were randomly divided into four groups (n = 10), according to the preparation height and luting agent: Group 1 – tooth prepared with 5 mm of height and crowns fixed using self-adhesive resin cement (RelyX™ U100, lot #318258; 3M ESPE, Seefeld, Germany), according manufacturer's directions; Group 2 – tooth prepared with 5

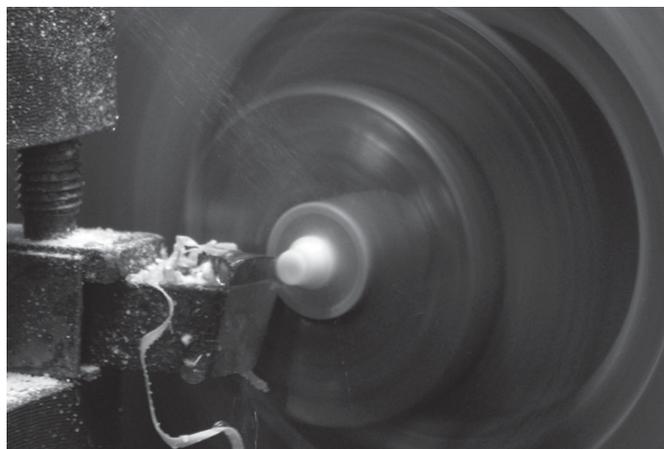


Fig. 1 - Preparation on mechanical lathe.

mm of height and crowns fixed using zinc phosphate cement (lot #06809007 powder and lot #0040807 liquid, SS White, São Paulo, SP, Brazil), according manufacturer's directions; Group 3 – tooth prepared with 3 mm of height and crowns fixed using self-adhesive resin cement as group 1; and Group 4 – tooth prepared with 3 mm of height and crowns fixed using zinc phosphate cement as group 2.

The preparation heights are presented in Figure 2. Standardization of height was done using a cylindrical diamond bur (#1090; KG Sorensen) in a handpiece under water cooling. The last cut was made in a groove shape, with 0.5 mm depth in the proximal walls along the tooth long axis to guide the insertion pathway of the cast crown. Areas of pulp chamber exposure were closed with a light-cured resin (Z350; 3M ESPE, St. Paul, MN, USA). Specimens were stored in constantly renewed saline until the luting procedure.

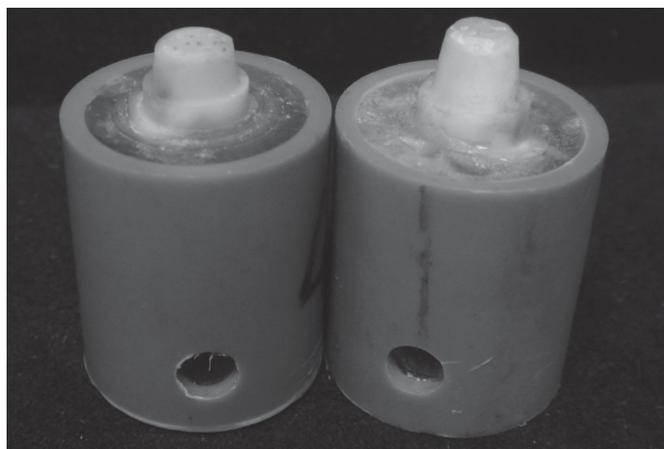


Fig. 2 – Preparation heights: 3 mm (left) and 5 mm (right).

Crown cast

Crowns were waxed directly on the prepared teeth⁶. A handle was done on each crown for future joining to the testing machine, using wax wires (Bego, Bremer, Germany) with 1.5 mm of diameter. The wax crowns were invested with proportion of 100 g for 22.5 ml of liquid (Begosol; Bego) and 2.5 mL of water, according to the manufacturer's directions. The crowns were cast in a NiCr alloy (Wironia;



Fig. 3 - Cast crowns prepared for luting.

Bego). After divesting, fit was checked, the internal surfaces of the cast crowns were airborne-particle abraded with 110- μ m aluminum oxide (Korox 110; Bego) under 2 bar of pressure, and cast crowns prepared for luting as presented in Figure 3.

Crown luting

The preparation was cleaned using rotary brush and pumice in low-speed hand piece, washed and then dried using sterile cotton^{10,22}. Metallic crown were sandblasted (Microjet; Bio Art Equipamentos Odontologicos Ltda, Sao Carlos, SP, Brazil) with a 50- μ m particle stream, cleaned with alcohol and water, and dried with an air stream free of water or oil. Luting procedure was performed according to each manufacturer's instructions.

The crowns were finger pressed after insertion on the preparation, and were then subjected to constant axial pressure of 5 kg for 10 min using a custom-made press that allowed cement flow and correct crown fit on the preparation^{12,19,23} (Figure 4). Excess material was removed with a sharp explorer.

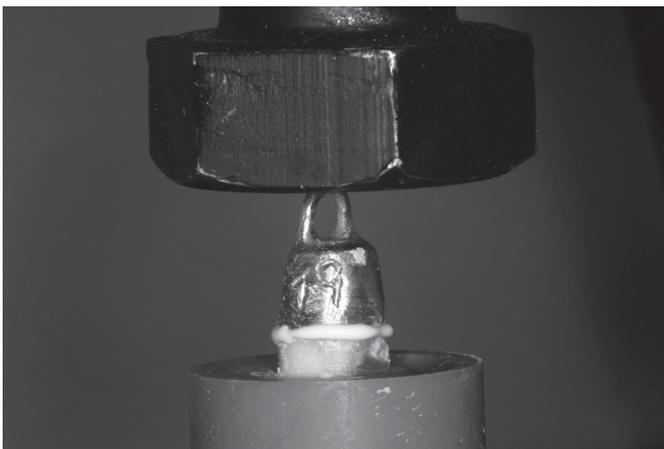


Fig. 4 - Standardization of luting load.

Excesses of RelyX U100 were first light-cured using LED curing unit (Radii Cal; SDI, Australia; 1.200 mW/cm²) for 2 s to facilitate the removal. The margins of the preparation were then light-cured for 30 s at each face. Specimens were stored in distilled water at room temperature for 10 days before of the tensile strength test.

Tensile Strength Test

Crown retention was measured by applying a tensile force to the loop attached to the cast crown in a universal testing machine (EMIC DL 20000, São José dos Pinhais, PR, Brazil) at a cross-head speed of 0.5 mm/min^{13,24}. Each specimen was positioned on the lower part of the machine. The upper part of the testing machine had a 2.5-mm diameter S-shaped steel hook to which the handles of crowns were connected (Figure 5). Tensile force values required to separate the crowns (kgf) was recorded by machine's software. Lavenes's test was applied to verify the homogeneity of variances, as well as the Kolmogorov-Smirnov's test to verify data distribution. As normal distribution was observed, statistical analysis was performed by two-way ANOVA and Tukey's post-hoc test at 5% significance level. Visual examination of the debonded surfaces of the teeth and crowns was performed.



Fig. 5 - Specimen positioned in the testing machine.

Results

The results are presented in the Table 1. Both factors, height preparation and luting cement had significant influence on crown retention. Crowns cemented with RelyX U100 (groups 1 and 3) presented significantly higher mean tensile strength values ($p < 0.0001$) than crowns cemented with zinc phosphate cement (groups 2 and 4). The 5-mm preparation height promoted significantly higher mean tensile strength values than 3-mm preparation height ($p = 0.018$). There was no significant interaction between the factors ($p = 0.847$).

Table 1. Means (standard deviations) tensile strength values (kgf) for the different experimental conditions.

Luting agent	Preparation height	
	5 mm	3 mm
Self-adhesive resin cement	39.6 (13.0) Aa	32.2 (7.9) Ba
Zinc phosphate cement	16.9 (8.1) Ab	10.6 (3.2) Bb

Means followed by different uppercase letters in the same line and different lowercase letters in the same column are significantly different ($p < 0.05$).

Debonded adhesive failure types were predominantly found. For groups 1 and 3, the failures were adhesive between cement and preparation on the axial surfaces; and between cement and crown on the occlusal surface. For groups 2 and 4, on the other hand, the failures were adhesive between cement and crown on the axial surfaces; and between cement and preparation on the occlusal surface.

Discussion

Retention is considered an important requirement in the fixation of prosthetic crowns, and its achievement is dependent on some factors, namely favorable relation between surface geometry of the prepared tooth and the definitive restoration^{4,9,25-28}. Clinically, a crown would hardly undergo such great tensile efforts as those applied in this study, but the tested experimental conditions serve as parameters to evaluate different properties and behaviors of the materials used. According to the obtained results, minimum occlusal reduction during preparation contributes significantly to increase the retention⁶⁻⁸, regardless of the type of luting agent used.

The results of the present study may be explained by the fact that higher preparation height promotes greater superficial area with the crown^{5,26,28-29}. Although other factors may influence on crown retention, the preparations were standardized (cervical diameter, taper, roughness, piece fit), thus eliminating or minimizing the interference of these variables on the results. Rubo et al.⁵ concluded that preparation 2 mm higher contributes significantly for a better retention of crowns. Other studies have shown greater crown retention for preparation with greater height^{24,29-32}.

Concerning of the luting agents, the results showed greater retention (Table 1) for the RelyX™ U100 self-adhesive resin cement when compared to the zinc phosphate cement, probably due to the adhesive capacity of the resin cement to dentin by hybrid layer formation, improving the retention compared to conventional cements^{13,17-18}. Moreover, better mechanical properties of resin cement in relation to zinc phosphate cement also influence their tensile, compressive and shearing strengths. The lower tensile strength of the zinc phosphate cement may be related to its ceramic composition, which makes this material friable and less resistant to tensile forces³³.

Zinc phosphate cement does not have chemical adhesion to any dental substrate, acting only as luting agent by mechanical or frictional retention. Thus the height, taper and area of the preparation important aspects for its success as a luting material^{32,34}. Therefore, in situations where preparation retention is deficient, for example, a short clinical crown and accentuated taper of the preparation, the choice for a luting agent lies on resin cement, leading to a more favorable clinical prognosis¹⁵. However, the difference in tensile strength between the luting agents found in this study does not contraindicates use of the zinc phosphate cement because the retention values obtained were higher than the forces expected clinically, which is around of 4 kgf²³.

Tjan and Li³⁵ compared the retention of cast crowns luted

with adhesive resin cement (Panavia Ex[®]) and zinc phosphate cement (Flecks[®]), concluding that the resin cement Panavia Ex[®] provided almost twice the retention values given by zinc phosphate. Browning et al.¹² compared the retentive capacity of three cements (resin, glass ionomer and zinc phosphate) on crown preparations that presented adverse conditions for retention, and found that the resin cement showed significantly higher retention values than the conventional cements. The findings of other studies^{13,36} are in agreement with ours.

Piwowarczyk et al.¹⁶ compared the shear bond strength of luting agents used in fixed prostheses, stating that the self-adhesive resin cement RelyX[®] Unicem did not differ significantly from other conventional resin cements. However, it presented significantly higher bond strength than glass ionomer, zinc phosphate and resin-modified glass ionomer cements. Martins Pinto³¹ verified the tensile strength of metal crowns luted with RelyX™ Unicem, RelyX™ ARC and Hy bond[®] (zinc phosphate). The author observed higher retention for self-adhesive resin cement RelyX™ Unicem than for the other cements.

Under the tested conditions, it may be concluded that self-adhesive resin cements should be preferred for luting of metal crowns and minimum occlusal reduction should be done on preparation. Further studies using other variables such as thermal cycling, cyclic loading and long-term storage should be performed to confirm the results and hypotheses addressed in the present study.

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