Influence of core-finishing intervals on tensile strength of cast posts-and-cores luted with zinc phosphate cement

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Abstract: The core finishing of cast posts-and-cores after luting is routine in dental practice. However, the effects of the vibrations produced by the rotary cutting instruments over the luting cements are not well-documented. This study evaluated the influence of the time intervals that elapsed between the cementation and the core-finishing procedures on the tensile strength of cast posts-and-cores luted with zinc phosphate cement. Forty-eight bovine incisor roots were selected, endodontically treated, and divided into four groups (n = 12): GA, control (without finishing); GB, GC, and GD, subjected to finishing at 20 minutes, 60 minutes, and 24 hours after cementation, respectively. Root canals were molded, and the resin patterns were cast in copper-aluminum alloy. Cast posts-and-cores were luted with zinc phosphate cement, and the core-finishing procedures were applied according to the groups. The tensile tests were performed at a crosshead speed of 0.5 mm/min for all groups, 24 hours after the core-finishing procedures. The data were subjected to one-way analysis of variance (ANOVA) and Tukey's test ($\alpha = 0.05$). No significant differences were observed in the tensile strengths between the control and experimental groups, regardless of the time interval that elapsed between the luting and finishing steps. Within the limitations of the present study, it was demonstrated that the core-finishing procedures and time intervals that elapsed after luting did not appear to affect the retention of cast posts-and-cores when zinc phosphate cement was used.

Descriptors: Dental Polishing; Post and Core Technique; Tensile Strength; Zinc Phosphate Cement.

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Introduction

Severely damaged teeth with large structural loss often require posts-and-cores to retain the final restoration.[1-3] The restorative modalities for root-filled teeth have been the subject of important research over the years, aimed at making the root/post complex more resistant to masticatory loads.[4] Cast posts-and-cores have been used routinely to restore root-filled teeth with moderate to severe destruction, especially single-rooted teeth.[2,5] This is mainly because cast posts-and-cores can be adapted to different forms of canals, and, due to their proven clinical success, they are still widely used in dentistry.[6]

The longevity of restored teeth depends on both the remaining tooth structure and the efficiency of the restorative procedure.[7] Prosthesis retention is essential for clinical success. Several studies have demonstrated that variables related to the retention of cast posts-and-cores—such as length,[8] surface characteristics,[9] diameter,[10] wall inclination,[11] luting cement type,[12] and luting technique[13]—are directly related to the longevity of the final prosthesis. While the finishing of the coronal portion of cast posts-and-cores after luting is routine in dental practice, this procedure can directly influence the strength of the zinc phosphate cement, which is the common choice for luting metallic retainers.[14]

Ultrasonic vibration is known to weaken brittle zinc-phosphate-based cements, simplifying the removal of cast posts-and-cores and crowns when necessary.[15,16] Reports evaluating the ability of ultrasound instruments to remove luted posts from teeth have shown a direct correlation between the vibrations generated and post loosening.[17,18] Because of the characteristics of the handpiece mechanism, the cutting instruments, and the speed of rotation, rotary instrumentation produces vibrations equivalent to those produced by ultrasound instruments.[19] Additionally, the vibrations produced by rotary diamond instruments in high-speed handpieces may affect the post/tooth cement layer, consequently jeopardizing post stability and retention.[20]

Few evaluations have been conducted about the effects of finishing procedures on the strengths of different luting cements.[21,22] This is significant, since the vibrations produced by finishing with rotary cutting instruments mounted on dental handpieces may be responsible for the reduced properties of these materials.[20] Therefore, it is important to assess the influence of core-finishing procedures on the retention and stability of posts-and-cores to avoid interruptions in the longevity of restorations.

Thus, the aim of the present study was to assess the effects of core-finishing procedures, after different time intervals, on the tensile strength of cast posts-and-cores luted with zinc phosphate cement. The null hypothesis was that the time elapsed between the luting of the cast post-and-core with zinc phosphate cement and the core-finishing procedures would not influence the tensile strength of these retainers to endodontically treated roots.

Methodology

Forty-eight freshly extracted bovine incisors of similar sizes and shapes were selected according to crown dimensions after measurement of the buccolingual and mesiodistal widths in millimeters, allowing for a maximum deviation of 10% from the average.[23] Debris was removed by means of hand-scalers, and teeth were stored in 0.1% thymol solution prior to being tested. The crowns of all the teeth were sectioned perpendicularly to the long axis, 15 mm from the apex, with a water-cooled diamond disk (No. 7020; KG Sorensen, Barueri, Brazil).

Root canals were instrumented by the step-down technique, with 1.0% sodium hypochlorite (Cloro Rio 1.0%; São José do Rio Preto, Brazil), filled with gutta-percha and zinc oxide-eugenol sealer (Endofill; Dentsply, Petrópolis, Brazil). Initially, the post space was created with heated instruments, and the residual gutta-percha was then removed with Gattes-Gliden burs (2, 3, 4, Dentsply Maillefer, Ballaigues, Switzerland), standardizing the post space to 11 mm and preserving 4 mm of root filling at the apex. Root canal walls were then enlarged with a 1.5-mm-diameter bur (Largo Peeso Reamer, No. 5, Dentsply Maillefer). The roots were perpendicularly embedded in autopolymerizing acrylic resin cylinders (Dencrilon; Dencril, Pirassununga, Brazil), and pre-fabricated polycarbonate patterns were used for cast post-and-core fabrication (Nucleojet; Ângelus, Londrina, Brazil).[23] Reline of patterns was carried out with the autopolymerizing acrylic resin in the individual root canal of each specimen (Duralay; Reliance Dental Mfg. Co., Worth, USA) until passive retention was achieved. The individual patterns were adjusted in the respective specimens, and the coronal portion was defined as a cylindrical core.

A circular orifice was created in the coronal portion of the acrylic pattern in a mesiodistal direction by means of a spherical carbide bur (No. 2; KG Sorensen) to allow for attachment of the tensile device. A graphite stick was then introduced into the orifice to maintain the integrity of the aperture during casting. The patterns were invested, cast in copper-aluminum alloy (Duracast MS; Odonto Comercial Importadora, São Paulo, Brazil) by the lost wax technique, and sandblasted with aluminum oxide particles (50 μm) under 2 bar for 10 s. The correct adaptation of the cast posts-and-cores to their respective specimens was confirmed by radiography prior to the luting procedures.

The root canals were cleaned with distilled water and dried with absorbent paper points prior to cementation. The cast posts-and-cores were luted with zinc phosphate cement prepared according to the manufacturer's instructions (Zinc Cement; SS White, Rio de Janeiro, Brazil). The cement was applied over the cast post-and-core surfaces and inserted into the root canal by means of lentulo drills (Dentsply Malleifer). The retainers were then positioned in the root canals, and a constant load of 50 N was applied for 10 min in a static loading device with a 4-mm cylindrical point, to standardize the cement layer thickness. The specimens were randomly distributed among four groups (n = 12 each): GA, control (without core finishing); GB, GC, and GD, subjected to core finishing at 20 min, 60 min, and 24 h after cementation, respectively.

Finishing of the cores was achieved with the use of a high-speed handpiece (EXTRAtorque 605C, KaVo do Brasil, Joinville, Brazil) and coarse, tapered diamond burs (No. 3146; KG Sorensen) under copious water irrigation. A new diamond bur was used for the core finishing of each specimen and was then discarded. One experienced operator was pre-calibrated by performing the finishing steps in pilot specimens made for this purpose, to standardize the position of the handpiece and the diamond bur in relation to the core long-axis, the manual pressure applied to the metallic cores, and the time required for completing this procedure, so that the technique could be regarded as reasonably consistent.[21] This operator performed all finishing steps within 5 min (3 min on the axial surface and 2 min on the occlusal surface), as another way of standardizing the finishing procedure (Figures 1A–1E). The resulting specimens in each experimental group were stored in distilled water at 37°C for 24h prior to being tested.

Next, the specimens were attached to a self-aligning tensile device in a mechanical testing machine (DL 2000; EMIC, São José dos Pinhais, Brazil) and subjected to a tensile strength test at a crosshead speed of 0.5 mm/min (Figure 2). Each specimen was tested to failure. At any sudden dislodging of the retainer, the test was interrupted, and the tensile strength (N) required for dislodging the posts was recorded by the software (TESQ, EMIC). One-way analysis of variance (ANOVA) was then applied at the $\alpha = 0.05$ confidence level.

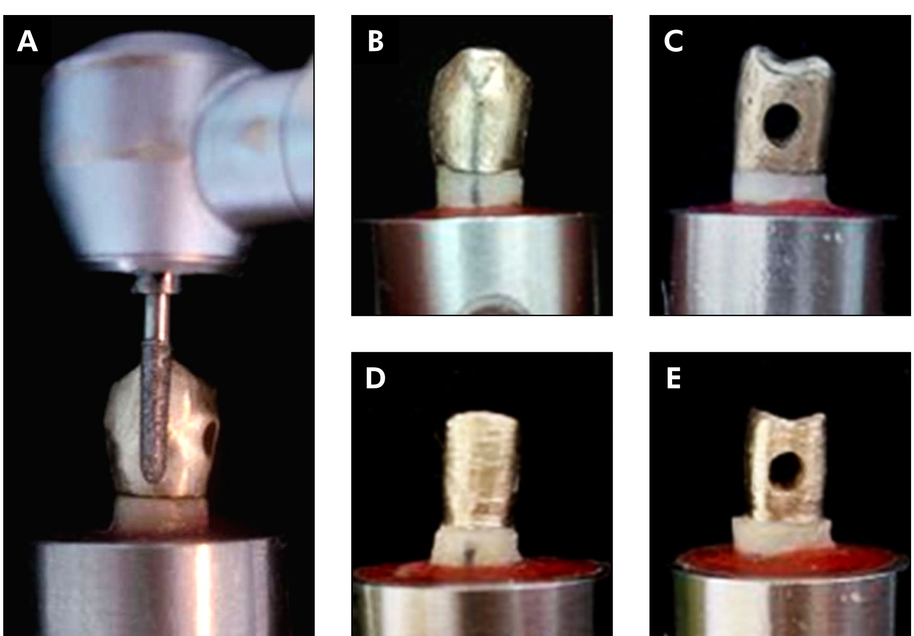

Figure 1 - Core-finishing procedures: **(A)** diamond rotary cutting instrument in position; **(B, C)** buccal and proximal aspects of the specimens before cast post-and-core finishing; **(D, E)** buccal and proximal aspects of the specimens after cast post-and-core finishing steps.

Table 1 - One-way ANOVA for tensile strength values (α = 0.05).

Variation source	Sum of squares	Degree of liberty	Medium square	Statistical F	Significance (P)
Between groups	9822.835	3	3274.278	918.0	0.440
Within the groups	153432.067	43	3568.188		
Total	163254.902	46			

Figure 2 - Tensile strength test loading apparatus.

Table 2 - Mean tensile strengths (N) and standard deviations (SD) for tested groups.

Groups	Tensile strength (N) ± SD
GA	251.55 ± 55.64^A
GB	213.39 ± 73.66^A
GC	224.13 ± 53.94^A
GD	239.62 ± 54.87^A

*Same capital letters indicate non-significant difference between groups in rows (α = 0.05).

Results

Shapiro-Wilk and Kolmogorov-Smirnov tests revealed normality and homoscedasticity of the data. One-way ANOVA showed no significant differences among the groups tested (Table 1). Table 2 shows the mean tensile strength values (N) and standard deviations for each experimental group. Despite the lack of verifiably significant differences among the groups for tensile strength according to core-finishing time intervals (P = 0.440), the GA group (control) showed slightly higher tensile strength numeric values, followed by the GD (finishing after 24 h), GC (finishing after 60 min), and GB (finishing after 20 min) groups.

Discussion

The null hypothesis was fully accepted; results showed no significant differences in mean tensile strengths for the experimental groups tested. The core-finishing procedures performed at different time intervals after cast posts-and-cores were luted with zinc phosphate cement did not influence the tensile strength of these retainers to endodontically treated roots (Tables 1 and 2).

These findings are in agreement with the results reported by Lund and Wilcox, who found no differences in retention between posts whose cores had been prepared 1 h after cementation and those that had been left unprepared.[24] The findings are also in accordance with those from a recent study that also found no differences in tensile strength for posts-and-cores left unprepared and for those prepared 15 min or 7 d after cementation.[25] In contrast, Al-Ali *et al.*[21] found that the retention of posts-and-cores prepared 15 min after cementation was lower than that of those prepared 1 and 24 h after cementation. The different time intervals that elapsed between the luting of the cast posts-and-cores and the core-finishing procedures may have produced various effects on microleakage at the cement-tooth interface.[24] However, these intervals were not enough to affect the retention of cast posts-and-cores in the present study, since other factors involved in post retention—such as length, diameter, wall inclination, surface characteristics, and luting cement—did not appear to be compromised.

The core-finishing procedures involving high-speed handpieces and diamond burs produce vibrations that can be compared with those produced by ultrasound devices.[19,21] These vibrations transfer intense mechanical waves to the cementing layer between the metallic post and the root canal walls, dislodging the post as a result.[26] The finishing time used for cast posts-and-cores, then, constitutes an important factor to be analyzed, becoming a variable that can produce differences between and among studies. A core-finishing procedure applied for time intervals longer than 5 min could result in retention values different from those observed in this study, since the utilization of variable times up to 12 min of ultrasound application on metallic/metal-ceramic crowns significantly reduces the strength needed for crown removal.[27] Thus, the longer the ultrasound application time, the higher the probability of damage to the cement layer.[15] This is true mainly for zinc phosphate cements, which require less time for post removal by ultrasonic vibration compared with other luting cements.[26] Despite the findings of Lund and Wilcox, who reported that the preparation did not affect the tensile strength of cast posts-and-cores luted with zinc phosphate cement, they observed that post retention was reduced with increased severity of preparation, showing that the time expended on preparation is indeed relevant.[24]

The zinc phosphate cement setting period has been defined as between 2 and 8 min. However, studies have shown that this cement achieves 70% of its final strength during the first setting hour, and its maximum strength is attained only in the next 24 h.[28] In this study, the cast posts-and-cores were subjected to tensile strength tests 24 h after the core-finishing procedures were carried out. Perhaps if the tests had been carried out immediately after the finishing procedures, the tensile strength results would have been lower, similar to already-reported values.[29] The pre-testing waiting time could be explained by attempts to follow clinical recommendations that the core-finishing process should not be rushed for at least several minutes after the initial hardening of the zinc phosphate cement, to reduce the risk of water/saliva contact, because the material is very soluble in the non-matured state.[30]

In spite of the care taken for standardization of the specimens and methodology, some variability was observed in the tensile strength values for intra-group comparisons. This was probably caused by differences inherent in the root anatomy, in the molding and cast procedures, and in the characteristics of the luting material itself. This variability is common in studies testing the tensile strength of cast posts-and-cores luted with zinc phosphate cement.[21] Additionally, the length, diameter, geometric design, surface configuration of the retainer, and the cement type are also directly related to the retention and stability of cast posts-and-cores in the root canal.[8] Thus, conditions different from those used in this study can result in different tensile strength values for cast posts-and-cores.

Increased time intervals between core-finishing procedures after cast post-and-core luting with zinc phosphate cements can result in higher rates of retention.[21] However, the results of the present study confirm that the initial adjustments and finishing of these retainers can be made in the same session as luting, if the correct cement setting time is ensured prior to preparations with high-speed handpieces and diamond burs. Since this study was conducted in laboratory conditions, it presented some intrinsic limitations, such as the absence of mechanical/thermal cycling of the specimens and the use of a single luting cement type and dental alloy for casting posts-and-cores. Clinical assessments would be of benefit.

Conclusions

Within the limitations of this *in vitro* study, the following conclusions could be drawn:

1. The tensile strength of the cast posts-and-cores luted with zinc phosphate cement was not influenced by the core-finishing procedures.
2. The time intervals for core finishing of cast posts-and-cores after luting with zinc phosphate cement did not seem to be a significant factor in retention when the finishing procedures took up to 5 min.
3. Initial adjustments and core finishing of cast posts-and-cores luted with zinc phosphate cement can be performed in the same session as luting if the cement setting time is ensured prior to preparation.

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