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Original

Removal resistance of glass-fiber and metallic cast posts with different lengths

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Abstract: This study evaluated the strength required to remove glass-fiber and metallic cast posts with different lengths. Sixty endodontically treated canines were included and their roots were embedded in acrylic resin after discarding the crowns. Samples were randomly assigned to 3 groups according to the post length (n = 20): I- 6 mm, II - 8 mm and III- 10 mm. Each group was divided into 2 subgroups based on the post material (n = 10): A- glass fiber or B- metallic cast. Post-space was prepared with Fibrekor Post Kit attached to a parallelometer. In subgroup A, prefabricated glass fiber posts from Fibrekor Post Kit were utilized. In metallic post group (subgroup B), an impression of post space was obtained, followed by casting. All posts were luted with Panavia F cement. A universal testing machine determined the force required to dislodge each post. ANOVA analysis indicated significant differences (*P* < 0.01) among post length. Tukey test showed that posts with 10 mm-length showed higher resistance on removal than posts with 6 mm-length. Posts with 8 mm-length did not exhibit difference when compared to 6 and 10 mm posts. No significant differences (*P* > 0.05) were observed between the tested post materials. It was concluded that the type of post did not influence the removal resistance and that posts with 10 mm-length required greater force to be dislodged. (J. Oral Sci. 48, 15-20, 2006)

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Introduction

Endodontically treated teeth with extensive loss of coronal structure are usually restored with a post and core over which a crown is constructed. This procedure requires partial removal of the root canal filling to prepare adequate space for the post and retention of the intracanal post is determined by mechanical features (1-5).

Cast posts and cores have been the standard for many years and are still used by clinicians (6,7,8). These may be indicated when a tooth is misaligned or when the coronal structure is minimal and the core must be angled in relation to the post to achieve proper alignment (4,9) While metallic posts are generally easy to retrieve when endodontic retreatment is necessary (6,9), they require laboratory charges (2,9), removal of large amounts of sound tissue (10) and the core stiffness is different from dentin (7,11). The major disadvantage of metallic posts is the dark shadow that appears on the marginal gingiva, which is caused by the oxidation process (9,12).

Together, these concerns have led to the development of innovative post systems. Among the materials used for aesthetic procedures, glass-fiber posts have gained popularity due to favorable biomechanical properties (10,13-15). They are more flexible than metallic cast posts and forces are better distributed, resulting in fewer root fractures (9,16). Besides, these prefabricated posts are advantageous in cases where the coronal tooth structure is not extensively lost (5,13,16).

It is generally agreed that post retention is the major factor in survival of restorations (17-20). Post configuration strongly affects dowel retention (21). The choice of posts is also pre-determined by the root canal dimension (11) and limited by the size of the root (5,9,21). In this respect, it has been shown that the use of a longer, rather than thicker, post influences the retentive strength positively (21,22). Moreover, conservation of sound dentin and proper apical sealing during post preparation are routinely recommended to ensure adequate retention (6) and avoid microleakage through the remaining filling (3,23,24).

Knowledge of the factors influencing the relatively low retentive properties of posts has become even more important and the need for clarification of the effect of post length remains open to question, as different opinions related to retention still exist (9,11,20-22). The purpose of this study was to assess the in vitro removal resistance of glass-fiber and metallic cast posts of different lengths.

Materials and Methods

Sixty sound maxillary human canines, extracted within a six-month period for endodontic or periodontal reasons and stored in 0.9% saline solution, were cleaned with scaler and dental prophylaxis cups with water/pumice slurry. Each tooth was examined under a 10 × stereomicroscope (Nikon. Instrument Group, Melville, NY, USA) to exclude those with structural defects. All selected teeth had a single canal and straight roots approximately 15 mm long.

Teeth were sectioned transversally 1 mm below the cementoenamel junction with diamond discs (KG Sorernsen, Barueri, Brazil) under water-cooling. Crowns were discarded and roots were individually embedded in acrylic resin (Jet, Clássico, São Paulo, Brazil) using rectangular aluminum molds. Following material polymerization, root canals were manually instrumented to a working length of 14 mm (1 mm above apex) with K-files (Dentsply-Maillefer, Ballaigues, Switzerland) up to a # 50 master apical file. During the instrumentation, canals were irrigated with 1% sodium hypochlorite. Final irrigation was done with 10 ml of distilled water and the canals were aspirated and dried with absorbent paper points (Dentsply-Herpo, Petrópolis, Brazil). Root canals were obturated with gutta-percha points (Dentsply-Herpo, Petrópolis, Brazil) and Sealer 26 (Dentsply, Rio de Janeiro, Brazil) using the lateral condensation technique and accessory gutta-percha points.

Root canal entrances were swabbed with alcohol and sealed with a non-eugenol, self-setting temporary filling material (Vigodent, Rio de Janeiro, Brazil). The specimens were stored in distilled water at 37°C for 144 hours, corresponding to three times the endodontic sealer setting time.

Samples were randomly assigned to three equal groups, according to their root canal lengths and, therefore, according to post length (n = 20): I- 6 mm, II- 8 mm and III- 10 mm. Post spaces were prepared with parallel burs of FibreKor Kit (Pentron, Wallingford, USA) on a low-speed hand piece (Dabi Atlante, Ribeirão Preto, Brazil) attached to a parallelometer (ELQuip, São Carlos, Brazil). In sequence, each group was randomly divided into 2 subgroups according to post material (n = 10): A- glass fiber or B- metallic cast.

Prefabricated posts from FibreKor Post Kit (Pentron, Wallingford, USA) were used as glass-fiber cores. The posts presented by this system are composed of longitudinal glass fibers combined with a well-built matrix of composite resin.

In the other experimental group, cast posts were fabricated from the root canal impressions taken with chemically activated resin (Duralay; Reliance Dental, Worth, IL, USA) and pin-jet posts (Ângelus-Odontológika, Londrina, Brazil). Sequentially, specimens were embedded in silicon rings with phosphate investment (Polidental, São Paulo, Brazil) and were cast in copper-aluminum alloy (Goldent L.A., São Paulo, Brazil). Cast posts received an aluminum oxide blast and were adjusted to fit the root canals.

Before cementation, 37% phosphoric acid gel (Etching gel, 3M Dental Products, St Paul, MN, USA) was applied for 15 seconds in all post spaces using microbrush tips. Canal spaces were irrigated for 20 seconds with distilled water and dried with paper points. Later, Panavia F dual-cure resin cement (Kuraray, Osaka, Japan) was used according to the manufacturer's directions. Drops of each primer (Liquid A and Liquid B) were mixed for 5 seconds, and the mixture was applied to dentin, left undisturbed for 60 seconds and gently air-thinned to evaporate the volatiles. Proper ratios of the catalyst and universal pastes were dispensed, mixed for 30 seconds to create a smooth, uniform paste and the cement was inserted in root canals using lentulo spirals (Dentsply-Maillefer, Ballaigues, Switzerland).

The post-core settings were seated into the corresponding post space preparations, kept under digital pressure for 1 minute and the excess cement was removed. The resin cement was light-activated (Ultralux Eletronic; Dabi Atlante, Ribeirão Preto, Brazil) for 30 seconds from each surface (buccal, palatal, mesial and distal), resulting in a 2-minute light-curing cycle. Oxyguard II gel (Kuraray, Osaka, Japan) was applied to the superficial margins for 10 minutes and then removed with cotton rolls and water spray.

The samples were stored in distilled water at 37°C for 72 hours. Later, they were individually attached to a

Table 1 Mean values and standard deviations of strength (kN) required for post dislodgment, when using different post lengths

Post Type	Post length			Mean ± SD
	6 mm	8 mm	10 mm	
	0.1998	0.3180	0.5477	
	0.2813	0.2888	0.4596	
	0.2513	0.1770	0.3592	
	0.2176	0.2445	0.3063	
	0.3139	0.2254	0.3377	
	0.2891	0.3023	0.2871	0.3036 ± 0.0921 ^{A}
Glass-fiber	0.3345	0.2093	0.3545	
	0.2557	0.3847	0.3348	
	0.1027	0.3042	0.3205	
	0.3209	0.5165	0.2657	
Mean ± SD	0.2566 ± 0.0696	0.2970 ± 0.0979	0.3573 ± 0.0849	
	0.3132	0.1231	0.3712	
	0.2860	0.2303	0.5146	
	0.2560	0.3128	0.2897	
	0.1209	0.2786	0.4290	
	0.2667	0.2738	0.2954	0.2764 ± 0.0913 ^{A}
Metallic cast	0.1498	0.2580	0.3500	
	0.3332	0.4293	0.2629	
	0.2068	0.1902	0.3058	
	0.1015	0.2803	0.3246	
	0.2139	0.2511	0.2738	
Mean ± SD	0.2248 ± 0.0803	0.2627 ± 0.0795	0.3417 ± 0.0786	
Mean ± SD	0.2407 ± 0.0749 ^{a}	0.2799 ± 0.0886 ^{ab}	0.3495 ± 0.0800 ^{b}	

Capital letters indicate result of ANOVA ($P > 0.05$)
Superscript letters summarize Tukey's test results ($P < 0.01$)
Identical letters indicate statistical similarity

custom device apparatus to be held secure in a vertical position and to minimize the incidence of non-axial forces. A universal testing machine (Instron 4444; Instron Corporation, Canton-Massachusetts, USA) was used and the force was applied at a crosshead speed of 1.0 mm/min, until the posts were dislodged from the roots. The maximum force required to dislodge each post was recorded (kN). Posts removed from the root canal space were observed with a 40 × stereomicroscope (Nikon Instrument Group, Melville, NY, USA) to assess the failure modes.

Averages and standard deviations were calculated and data were analyzed by an analysis of variance (ANOVA) test using a factorial design with post length, and post type as independent variables. Multiple comparisons of means were performed by Tukey's statistical test.

Results

The resulting tensile force values necessary for dislodgment of posts, the respective averages and standard deviations are presented in Table 1.

The ANOVA test demonstrated significant statistical difference ($P < 0.01$) between the post lengths. However, significant differences ($P > 0.05$) were found neither between the glass-fiber and metallic posts, nor in the interaction between post length and material.

Tukey's analysis indicated that posts with 6 and 10 mm lengths were statistically different from each other ($P < 0.01$). Posts with 10 mm lengths exhibited the highest mean tensile strength, regardless of the post material. Posts with 8 mm length resulted in intermediate values that were not significantly different when compared separately to the groups of 6 and 10 mm.

After the strength test, posts removed from canal space showed cement adhering to the posts, indicating that adhesive failure were predominant in both glass-fiber and metallic post group. Figure 1 illustrates this result.

Discussion

Radicular posts contribute to the retention of prosthetic crowns to the remaining root (4,12,14,19) and prevent the passage of microorganisms and organic liquids through the interior of intraradicular canals (3,23,24). Nevertheless, clinical longevity of a post-and-core restoration is influenced by many factors, including the direction of occlusal load (21), thickness of remaining dentin (4-6,9), design of the dowel (1,11,17,21) and the type of post (9,10,25).

The outcomes of the present study revealed that glass-fiber posts and custom metallic posts showed the same performance. Similar results were reported in other studies (10,12,19,26), which verified the success rates of different types of posts.

It was reported that tooth preparation for a prefabricated post is easier than for a custom cast post (25). However, the post space preparation is remarkably similar for all techniques (6,25). The gutta-percha is removed to the desired depth and the root canal is prepared for the post (5,24,25). With all prefabricated post systems, the canal is shaped to receive a stock post (5,6,9). Less instrumentation is required for the custom-cast post preparation, as the post is customized to fit the available canal space (6,25). In our in vitro experiment, the root canals were not prepared manually but on a parallel device using a positioning tool. This ensured a reproducible root canal preparation and a standard post fit for each tested condition.

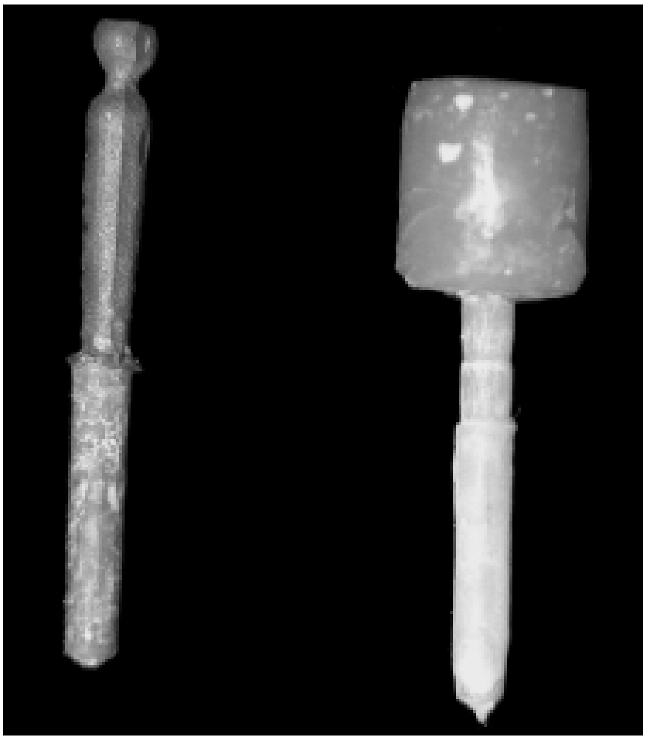

Fig. 1 Resinous cement adhered to metallic and glass-fiber posts indicating that adhesive failure was predominant in both groups

In theory, a post that flexes together with the tooth during function should result in better stress distribution and fewer fractures (9,13,14). However, a cast post is capable of resisting rotational forces because its design is in conformance with the natural root form (18). These speculations probably explain the result of similar retentions between posts.

The post analysis, after its removal from canal space, evidenced that an adhesive-failure mode was predominantly observed in all groups. Pithan et al. (26) also described the prevalence of adhesive failures in intracanal posts. These findings indicate that failure after testing mostly occurred at the interface between the luting agent and radicular dentin, and suggest that the strength values recorded were, in fact, representative and provided a reliable estimate of the removal resistance yielded by the tested conditions.

In terms of post length, biomechanical principles suggest that the length should be equal to or exceed the length of clinical crown in order to withstand forces present in the buccal cavity (6,8,25). Our results disclosed that the retention of post to root canal is directly proportional to the post length. These findings are corroborated by previous investigations (11,17,18,22).

Posts with 6 mm and 8 mm lengths correspond, respectively, to 40% and 53.3% of the root-length (15 mm) utilized on this study. These lengths are indicated in situations where the ideal post length (two thirds of the root) cannot be reached (1,8). When 10 mm post-length was applied in a root of 15 mm (66.6% or two thirds of root length), the vertical force necessary for dislodgment was greater than in the 6 mm post-length. Holmes *et al.* (11) reported that the stress peak occurred adjacent to the post and increased by 57% when post length was reduced from 13 mm to 8 mm. Conversely, Yang et al. (21) revealed that as dowel length increases beyond two thirds of the root, the stresses in the apical region increase and post length extension may damage the root apical sealing.

In this respect, it has been emphasized that an apical seal of 4 to 5 mm of gutta-percha should be maintained (23,24). Indeed, the post size should be compatible with the tooth anatomy (1,22) and preventive measures should be considered during the process of post space preparation (3,16). Since our study demonstrated that posts with 8 mm-length were similar to posts with 10 mm-length, we assume that in clinical circumstances of anatomical variations (short or curved roots), a post of 8 mm can be a viable alternative. Nissan et al. (20) also revealed no significant difference in retention of dowels with 8 mm and 10 mm-lengths.

It is important to highlight that it would not be appropriate to simply extrapolate these results to clinical situations, as it is not possible to achieve an exact simulation of the oral cavity environment. The determination of the ideal post length and remaining canal filling length should be based on scientific knowledge and on professional common sense, searching for equilibrium to achieve optimal biomechanical characteristics. Furthermore, the great variety of currently available dental materials is a crucial feature to be considered. The use of fiber posts will probably continue to grow and additional studies will challenge this relevant aspect of the restoration of endodontically treated teeth.

Based on these findings, and within the limitations of an in vitro study, it may be concluded that the type of intracanal post (glass-fiber or metallic cast) did not influence the removal resistance and that posts of 10 mm-length required greater force to be dislodged from root canals.

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