Original Article

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Fracture resistance of endodontically treated teeth restored with different intraradicular posts with different lengths

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Abstract

Aim: This study compared the resistance to fracture of endodontically treated teeth restored with different intraradicular posts with different lengths and full coverage metallic crowns. **Methods:** Sixty extracted human canine teeth were randomly divided into 6 groups. Groups CP5, CP75 and CP10 were restored using custom cast post and core (CP) and groups PF5, PF75 and PF10 were restored with provisional pre-fabricated tin post (PF) and composite resin core at 5 mm, 7.5 mm and 10 mm of intraradicular length, respectively. The specimens were submitted to dynamic cyclic loading and those that resisted to this load were submitted to load compression using a universal testing machine. Compressive load was applied at a 45-degree angle to the long axis of the tooth until failure. **Results:** Kruskal-Wallis one-way analysis of variance by ranks showed statistically significant differences among the groups ($p<0.0001$). However, when the means were compared using the Tukey's test, significant differences were noted between groups CP5 and CP10 and between groups CP10 and PF5. All groups presented root fractures and post displacements during mechanical cycling. All teeth in groups CP5 and PF5 failed the dynamic cycling test. **Conclusions**: This study showed that increasing intraradicular post length also increases resistance to fracture of endodontically treated teeth. On the other hand, most endodontically treated teeth restored with pre-fabricated tin posts (provisional posts) failed in the dynamic cycling test.

Keywords: post and core technique, prosthesis failure, mechanical stress.

Introduction

Numerous techniques for restoring endodontically treated teeth succeed depending on post length[1-2], its surface shape and configuration[1-7], amount of remaining dentinal structure[3-5], and techniques and materials used for build-ups[6-7]. Restoring endodontically treated teeth is a frequent task for clinicians.

Devitalized teeth are known to present higher risks of biological (inflammation) and mechanical (root fracture) failure than vital teeth[1,8]. The generally accepted explanation for this fact is the substantial loss of tooth structure for endodontic access, root canal and post preparation[6]. Posts are necessary to allow for retention

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for the subsequent coronal restoration[9]. The price for such an increase in retention, however, may become a risk of further damage to the tooth structure.

Cast posts have been accepted as the restorative component of choice for endodontically treated teeth when coronal structure is absent. Nevertheless, the use of prefabricated posts is growing, since most stages can be concluded at chairside and good prognosis is expected[3]. Some authors[3,10] argue that roots restored with cast posts show significantly higher internal tension than the ones with prefabricated posts.

Post length in relation to the root length is a controversial issue[11]. With the recent improvements in dentin bonding, good adhesion may positively influence the success of treatment[12-14]. In vitro studies have demonstrated that increasing post length results in better stress distribution along the post[2,15-16] and higher resistance to fracture[1]. Furthermore, a clinical study reported a higher survival rate relative to the increase in post length[7]. Nonetheless, other studies have shown minimal difference in stress distribution[17] and resistance to fracture[18] with the increase in post length.

It is important to note that it is not always possible to use a long post, especially when the root is short or curved. Several studies have suggested that it is important to preserve 3 to 5 mm of gutta-percha to maintain the quality of the apical seal[19].

The aim of this study was to evaluate the effect of length and type of prefabricated posts on the resistance to fracture of endodontically treated teeth. The research hypotheses are: 1) there is no difference in tooth fracture resistance between different prefabricated post lengths and 2) a significant difference exists between the types of posts.

Material and methods

Sixty freshly extracted human canine teeth were obtained from the University of Southern Santa Catarina (UNISUL) tooth bank for this study. The inclusion criteria were that all teeth should present similar anatomy and lengths varying between 15 to 18 mm. The teeth were kept in saline at room temperature during the experiments, following the guidelines of UNISUL Dental School's Ethics Committee (protocol #10.585.4.02.III).

The teeth were endodontically treated using the crown-down technique and filled by cold lateral condensation. K-files #20 to #35 (Dentsply Maillefer, Ballaigues, Switzerland) were used 1 mm short of the apex. Canals were irrigated with 2.5% sodium hypochlorite (Asfer Industrial Química, São Paulo, SP, Brazil) dried with paper points (Tamari; Tamariman Industrial Ltda., Macaçaruru, AM, Brazil). Gutta-percha points (Tamari, Tamariman Industrial Ltda.) and Sealer 26 (Dentsply Ind. e Com. Ltda., Petrópolis, RJ, Brazil) were used for root canal filling.

Following the endodontic treatment, the tooth crowns were sectioned perpendicular to their long axes using double-sided diamond disks (KG Sorensen, Barueri, SP, Brazil), leaving a standardized 15 mm root length. The teeth were then mounted in cylinders (30 mm high x 22 mm diameter), leaving 1.5 mm of the root exposed, and were randomly divided into 6 groups (n = 10). Groups CP5, CP75 and CP10 were restored with custom cast post and core and groups PF5, PF75 and PF10 with prefabricated tin posts (MetalPost, Angelus, Londrina, PR, Brazil). In groups CP5 and PF5, the posts were positioned 5 mm into the canal, in groups CP75 and PF75 7.5 mm and in groups CP10 and PF10 10 mm. The length of the post was standardized using a digital caliper.

Different post preparations were standardized using a #5 reamer (Largo; Dentsply Ind. e Com., Ltda.). Five millimeters of gutta-percha (apical to the cementoenamel junction - CEJ) were removed from each filled canal in groups CP1 and PF1, 7.5 mm in groups CP2 and PF2, and 10 mm in groups CP3 and PF3.

For the custom cast post and cores, impressions of the root canal were made using acrylic resin (Duralay; Reliance Dental Mfg. Co. Chicago, IL USA). The cores were standardized using preformed acetate matrices (TDV Dental, Pomerode, SC, Brazil), mounted (Cristobalite; Whip-Mix Corporation, Louisville, KY, USA) and cast in a Cu-Al alloy (NPG AalbaDent, Cordelio, CA, USA). Occasional minor casting imperfections were removed. The post/cores were fitted in their respective teeth. All posts were cemented with glass-ionomer cement (Vidrion C; S.S. White Artigos Dentários, Rio de Janeiro, RJ, Brazil) according to the manufacturer's instructions. The cement was spun into the canals using a lentulo spiral (Lentulo; Dentsply Maillefer, Ballaigues, Switzerland). The post was coated with cement before insertion into the canal and maintained under 5 kg pressure for 5 min. Pressure was removed and the cement was left to set. Cement excess was removed and the specimens were placed back in saline.

The prefabricated posts were cemented in the same manner as the custom cast post and core. The coronal aspect of the root was etched with 37% phosphoric acid for 30 s, washed for 30 s and gently air thinned. Two layers of the adhesive system Adapter Single Bond 2 (3M ESPE, Sumaré, SP, Brazil) were applied and light-cured for 20 s each using a curing light system with a 750 mW light intensity (Ultradent; Dabi Atlante, Ribeirão Preto, SP, Brazil). The core was built using the same acetate matrices as per the custom cast post and cores. Five increments of composite resin (Charisma Heraeus Kulzer, Hanau, Germany) were used for core build-up. Each increment was light-cured for 40 s (Ultraled; Dabi Atlante) with the light source at a 10 mm distance from the core.

All teeth were restored with a full-coverage cast metal crown. Silicone impressions were taken from the teeth before preparation (Aquasil, Dentsply, Konstanz, Germany) to facilitate the crown wax-up (Kerr Corporation, CA, USA). A Ni-Cr alloy (Durabond, São Paulo, SP, Brazil) was used to cast the crowns, which were cemented with glass-ionomer cement (Vidrion C; S.S. White Artigos Dentários, Rio de Janeiro, RJ, Brazil).

The post-core-crowned teeth were submitted to dynamic load with impact simulation. The tests were carried out with 5 specimens at a time and a frequency of 2 cycles per second, making up 250,000 thousand cycles with a peak load of 250 N at 37ºC (± 1º C). The load was applied to the palatal surface of the crowns at a 45º angle to the long axis of the tooth. Load values were noted at failure, i.e. root or post fracture or crown/post displacement.

Specimens that did not fail at the dynamic load test were then submitted to progressive static compression testing (Kratos, São Paulo, SP, Brazil) at 0.5 mm/min and 100 kg load cell. Compression was applied at a 45º angle to the long axis of the tooth.

Statistical analysis of the results was performed using Kruskal–Wallis one-way analysis of variance by ranks and multi-comparison Tukey's test at 5% significance level.

Results

There were statistically significant differences in fracture resistance among the groups ($p = 0.02$) (Table 1). Significant differences in fracture resistance were found comparing 10-mm-long custom cast post and core with 5-mm-long custom cast post and core and 5-mm-long pre-fabricated posts ($p < 0.05$).

The fracture patterns for all groups are found in Table 2. All teeth that were treated with 5 mm long posts failed during the fatigue test. Considering the 7.5 mm long devices, 5 of the custom cast post and core and 6 of the pre-fabricated posts failed during the fatigue test. Among the 10 mm long posts, 2 from the custom cast post and core and 7 from the pre-fabricated posts failed before compressive load.

Twenty-seven failures in the custom cast post and core groups occurred due to root fractures. However, in the provisional prefabricated post groups most failures occurred as a result of post fracture (18) or post displacement[8].

Table 1. Median, 25 percentile and 75 percentile of fracture resistance of the endodontically treated teeth. Kruskal-Wallis one-way analysis of variance by ranks and Tukey's test for multiple comparisons.

Group	Median	25%	75%
CP5	0.000 [ac]	0.000	0.000
CP75	8.800 [abc]	0.000	19.500
CP10	32.100 [b]	25.400	41.900
PF5	0.000 [ac]	0.000	0.000
PF75	0.000 [abc]	0.000	10.800
PF10	0.000 [abc]	0.000	14.000

Groups with same superscripts do not differ significantly (p<0.05) (Tukey's test). CP: Custom cast post and core (5, 7.5 and 10 mm); PF: pre-fabricated tin post (5, 7.5 and 10).

Discussion

This study confirms the hypothesis that there is a significant difference in the effect of post length on fracture resistance. Similarly the types of post also show significant differences.

It was observed that roots restored with a 10 mm custom cast post and core showed a significantly higher resistance to fracture ($p < 0.05$), when compared with shorter posts (5 and 7.5 mm). Such findings were also observed by Pereira et al.[1], Standlee et al.[2]. and Holmes et al.[16], who reported that an increase in post length resulted in higher resistance to fracture of endodontically treated teeth. This could be explained by the higher resistance of the Ni-Cr alloy and its higher module of elasticity[10] as well as a reduction of the wedge effect generated by shorter posts[2,15-16]. Furthermore, 50% of the 7.5 mm and 100% of the 5 mm custom cast post and cores failed during the mechanical cycling. In vitro studies have demonstrated that longer posts allow for an even stress distribution along their length, whereas shorter posts generate stresses that overload the tooth/post junction resulting in failure[2,15-16], which in the case of custom cast post and core means root fracture[12].

On the other hand, the present study demonstrated that an increase in length of prefabricated tin posts and composite resin cores did not increase the fracture strength in endodontically treated teeth. This could be explained because tin posts are rather malleable and present low hardness, which performs well as a provisional restoration and, because of this, the major failure when they were used was post fracture. The results of this study are in line with the findings of a previous one[14] in which the necessary stress that lead to failure of the resin/post combination was lower than the one to cause root fracture. The results of the present study show that most prefabricated posts failed the dynamic loading test due to post fracture or displacement.

Table 2. Percentage distribution of events according to the type of post placement and depth comparison among groups after dynamic and static load.

Depth (mm)	Event	Post type	
		Custom cast post and core	Pre-fabricated tin post
5.0	Tooth fracture	70%	10%
	Post release	30%	30%
	Post fracture	0%	60%
7.5	Tooth fracture	100%	10%
	Post release	0%	40%
	Post fracture	0%	50%
10	Tooth fracture	100%	20%
	Post release	0%	10%
	Post fracture	0%	70%

Restorative work using prefabricated posts and composite resin is a viable technique for endodontically treated teeth[3-6]. Failures of such restorations during occlusal loads may be considered a positive event because it preserves the remaining root[12]. However, such failures may occur under greater loads than those found intraorally. In the present study, the use of prefabricated tin posts suggests that their chances of achieving treatment success are limited, because the vast majority failed the mechanical cycling stage and those that did passed the test showed significantly lower results than those expected for the maximum physiological occlusal load[19]. The material the posts are made from could explain this result.

The limitations of this study include its in vitro background, which does not necessarily reflect the oral environment. For more significant results, future studies should incorporate thermocycling that can cause an alternating increase and decrease of deformation between material and tooth structure, thus changing the results.

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