Effect of post length on endodontically treated teeth: analyses of tensile strength

Jefferson Ricardo Pereira[1], Accácio Lins do Valle[2], Fábio Kenji Shiratori[3], Janaina Salomon Ghizoni[4]

[1]PhD, Department of Prosthodontics, Dental School, University of Southern Santa Catarina – UNISUL, Brazil
[2]PhD, Department of Prosthodontics, Bauru Dental School, University of São Paulo, Brazil
[3]MSc, Department of Prosthodontics, Bauru Dental School, University of São Paulo, Brazil
[4]MSc, Department of Prosthodontics, Dental School, University of Southern Santa Catarina – UNISUL, Brazil

Abstract

Aim: This study compared the tensile strength of endodontically treated teeth restored with different posts and cores with different post lengths. **Methods:** Sixty extracted intact canines were randomly divided into 6 groups. Groups CP1, CP2 and CP3 were restored with custom cast post-and-core and groups PF1, PF2 and PF3 were restored with prefabricated post and composite resin core, with different combinations of post length of 5,0 mm, 7.5 mm and 10 mm, respectively (n = 10). All teeth were restored with a total metal crown. A tensile loading was applied at a 180-degree angle to the long axis until failure. **Results:** The 2-way analysis of variance (á=0.05) showed statistically significant difference (p<0.001) among the groups. However, when the mean fracture forces for the groups were compared (Groups 1, 2, 3, 4, 5 and 6: 134.5 N (34.2), 178.9N (40.1), 271,5 N (55.9), 161.7 N (22.0), 216.1 N (42.0) and 257.9 N (41.0), respectively), no significant differences could be detected among the groups restored with prefabricated post and cast post-and-core. It was found significant differences when it was compared the different lengths for each type of post (p<.05). **Conclusions:** This study showed that increasing post length significantly increased the tensile strength of prefabricated posts and cast post-and-core used in endodontically treated teeth. On the other hand, significant differences were not found when comparing endodontically treated teeth restored with custom cast post-and-cores or pre-fabricated posts and composite resin cores with the same post length.

Keywords: post and core technique, composite resin, tensile strength.

Introduction

When coronal tooth structure is missing, custom cast post-and-core has been regarded as the "gold standard" in post-and-core restorations due to its higher success rate[1-2]. Alternatives to cast post-and-core have been developed. Prefabricated post systems simplify the restorative procedure because all steps can be completed chairside, and a clinical success can also be expected[1-10].

The intact teeth are known to present a lower risk of biomechanical failure than endodontically treated teeth[11]. The substantial loss of tooth structure during endodontic access, post-space preparation and cavity preparation are generally accepted explanations for the increased failure rates of endodontically treated teeth[12]. Posts are necessary to allow the clinician to rebuild enough tooth structure to retain restorations[13], but the 'price' for additional retention, may be an increased risk to damage tooth structure.

An unresolved problem using posts and cores is the length of a post relative to root length[14]. Laboratory studies have shown that increasing the length of the post in teeth with post-and-core systems results in a more favorable stress distribution along the post[15-17] and an increased post length improves the resistance of the restored tooth to fracture[10-18]. Furthermore, in a clinic study an increased survival rate has been correlated with increasing post length[11]. However, a previous study showed a minimal difference in stress distribution between varying post lengths[19], while other authors observed that an increase in post length as such will not necessarily increase the fracture resistance of the tooth[8,20].

The pattern of failure was changed since the introduction of pre-fabricated post and, because of this, the irreversible fracture of roots has become a rare occurrence[2-10]. However, adhesive failure, which is clinically expressed as decementation of the post, has become the main failure mode when pre-fabricated posts are used[21-23].

It is important to notice that it may not always possible to use a long post, especially when the remaining root is short or curved. It has been suggested that it is important to preserve 3 to 5 mm of apical gutta-percha to maintain the apical seal[24].

The purpose of this study was to evaluate the relative effect of post length (length of the vertical dentinal overlap of the crown) and type of post and core on the tensile strength when it is used to restore endodontically treated teeth. The research hypotheses were that there was a significant difference in the effect of post length on the fracture resistance; and there was a significant difference between the types of posts.

Material and methods

Sixty recently-extracted maxillary canines with similar root sizes (between 15 mm and 16 mm (measured with a millimeter ruler from the apex until the cementoenamel junction - CEJ) were selected from 173 maxillary canines extracted for periodontal reasons and stored in distilled water at 37º C during the course of the study. The inclusion criteria for tooth selection were teeth without cracks, caries, restoration, and/or roots longer than 15 mm. The roots were scaled wet with periodontal curettes. The crowns were reduced perpendicular to the root axis with double-faced diamonds discs (KG Sorensen, Barueri, SP, Brazil), leaving a standardized root length of 15 mm.

The endodontic treatment was done using a standard master apical file International Standardization Organization (ISO) 20 (Dentsply Ind. e Com. Ltda., Petrópolis, RJ, Brazil) that extended 1 mm beyond the apex and the preparation took place with a conventional step-back technique to an ISO 35 file (Dentsply Ind. e Com. Ltda.) at the apical constriction. The teeth were obturated by lateral condensation using gutta-percha points (Tanari, Tanariman Industrial Ltda., Manaçapuru, AM, Brazil) and an ISO 35 primary gutta-percha master cone (Tanari, Tanariman Industrial Ltda.). Root canal cement (Endometazone Ivory; Septodont Brasil, Barueri, SP, Brazil) was used as the sealer. After this, the teeth were randomly divided into 6 groups of 10 teeth each by drawling lots.

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

For the groups CP1, CP2 and CP3 the tooth was restored with a custom cast post-and-core. Impressions of the root canals were made with acrylic resin (Duralay, Reliance Dental Mfg. Co. Chicago, IL, USA). The cores were standardized using a core-forming matrix (TDV Dental, Pomerode, SC, Brazil). The patterns were invested (Cristobalite, Whip-Mix Corporation, Louisville, KY, USA) and cast in Cu-Al alloy (NPG, AalbaDent, Cordelia, CA, USA). After casting, small nodules were removed if present. The post-cores were sectioned and seated to their corresponding teeth. Resin modified glass ionomer cement (Rely X luting, 3M ESPE, St. Paul, MN, USA) was used to cement all posts. The cement mix was prepared according to the manufacturer's instructions and inserted into the canal with a lentulo spiral (Dentsply Ind. e Com. Ltda.) mounted on a low-speed handpiece. Cement was placed on the post and seated under 9 kg of pressure. After 2 min, the excess of the cement was removed. Even under pressure, the setting time of the cement was completed (5 min) and after 10 min the pressure was released and each specimen was returned to storage in distilled water.

For the groups PF1, PF2 and PF3 the canals were restored with prefabricated stainless steel, parallel-sided, serrated posts with a tapered end (number 5317, Screw-Post, Euro-Post Anthogyr S.A., Sallanches, France). In these groups the teeth were cemented with the same material and the same technique as used in the other groups. The coronal portion was made with composite resin material (Filtek Z250; 3M ESPE).The root surfaces and cervical dentin was etched with 37% phosphoric acid for 30 s, rinsed, and air dried. Two layers of bonding agent (Prime&Bond 2.1; Dentsply Ind. e Com. Ltda.) was applied to the cervical dentin and the coronal portion of the post and were light-polymerized for 20 s using a halogen light-curing unit (Ultraled, Dabi Atlante, Ribeirão Preto, SP, Brazil) with 450 mW/cm^2 light intensity. Cores were fabricated in a standardized form, using the same core-forming matrix as used in the other groups. Five increments of the composite resin were applied to complete the coronal core, each requiring 40 s of photo-activation. The tip of the light guide of the light-curing unit was positioned on the top of the core at a distance of 1 cm from the specimens.

All teeth were prepared with a round diamond bur (#3216; KG Sorensen) in a high-speed handpiece with water spray cooling (Super Torque 625 Autofix; Kavo do Brasil Ind. Com. Ltda., Joinville, SC, Brazil) to simulate a crown preparation with 1.5 mm of facial reduction with a chamfer finish line and 0.5 mm of chamfered lingual reduction and receive a total metal crown. All the finish lines, for all specimens and groups, were placed at the CEJ level. Crown wax (Kerr Corporation, Orange, CA, USA) patterns were then made for the specimens with the aid of the impression made using a vinyl polysiloxane impression material (Aquasil, Dentsply,

Konstanz, Germany) of the tooth prior to preparation. A lingual ledge was added to create a standard loading point. The wax patterns were sprued, invested (Cristobalite; Whip-Mix Corporation) and cast in a Ni-Cr alloy (Durabond, São Paulo, SP, Brazil) (Figure 1). Crowns were cemented using the same material used with the posts.

Teeth were embedded in acrylic resin (Clássico, Artigos Odontológicos S/A, São Paulo, SP, Brazil) poured into molds made of same material (30 mm in height, and diameter of 22 mm and a internal space, located in the center of the mold, with diameter of 10 mm and 20 mm in height) along their long axes using a surveyor (Bio Art Equipamentos Odontológicos Ltda., São Carlos, SP, Brazil).

The specimens were tested in a universal testing machine (Kratus K2000 MP, Dinamometros KRATOS Ltda, São Paulo, SP, Brazil (Figure 2) 7 days after post cementation. Each specimen was affixed in a apparatus that allowed it to be positioned at 180 degrees to the buccolingual long axis (Figure 2). The testing machine was set at a crosshead speed of 0.5 mm/min. The load was measured in N. Failure threshold was defined as the point at which a specimen could no longer withstand increasing load and the dislodgment of the crown or the post or fracture of the post-core complex, or root occurred. The mode of failure was recorder after the test using a x4 binocular loupe (Bio Art Equipamentos Odontológicos Ltda.).

Two-way analysis of variance (ANOVA) was used to determine the overall differences among the mean values of the groups and the overall variability within the groups. Tukey's multiple comparison test was used to establish inter-group differences ($\alpha = 0.05$).
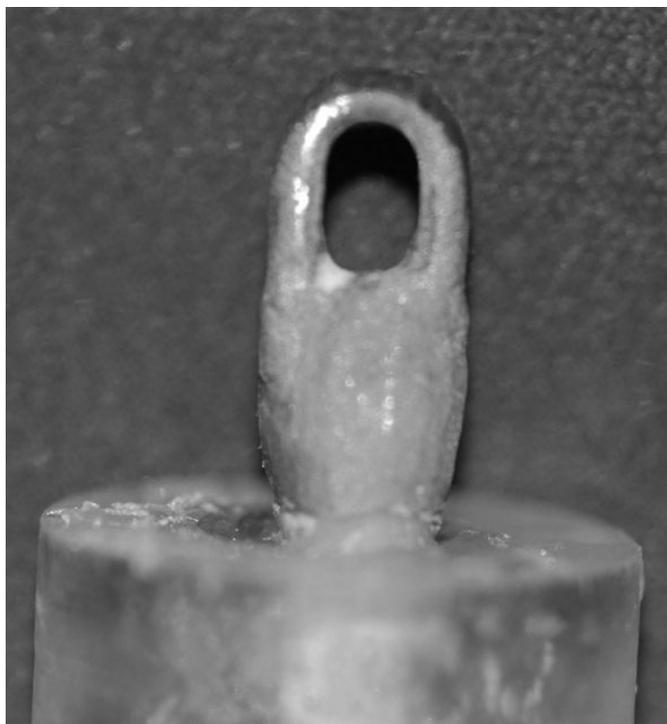

Fig. 2. Specimens subjected to tensile load at 180° in a universal testing machine.

Results

Table 1 summarizes the mean tensile strength for the 6 tests groups. ANOVA showed that 1 or more of the conditions were significantly different from each other ($p < 0.001$). The Tukey's test confirmed that the mean tensile strength for the group PF3 was significantly higher ($p < 0.001$) than those of groups PF2 and PF1 while the mean tensile strength for the group CP3 was significantly higher ($p < 0.001$) than those of groups CP2 and CP1. No statistically significant difference ($p > 0.05$) was found when comparing the mean tensile strengths of the groups with the same post length (Table 1).

Table 1. Resistance to failure values of test specimens, means (N) of test groups (standard deviation) and statistical comparisons

Groups	Mean (N)	SD
CP1	134.5[a]	(34.2)
PF1	161.7[ab]	(22.0)
CP2	178.9[bc]	(40.1)
PF2	216.1[c]	(42.0)
PF3	257.9[d]	(41.0)
CP3	271.5[d]	(55.9)

Groups with same superscripted letters are not significantly different at p< 0.05 (Tukey's test).

Discussion

Although this study was an in vitro experiment, it was observed that shorter posts were the main cause of post decementation independently if cast post-and-core or pre-

Fig. 1. Specimens embedded in acrylic resin before tensile strength testing in a universal testing machine.

fabricated post had been used. This result suggests that it is important to use posts as longer as possible to achieve the treatment success. The limitations of this study include the facts that in vitro design does not replicate oral conditions and that a single load was used to test the tensile strength of different posts used to restore endodontically treated teeth. For more meaningful results, future studies should incorporate thermal cycling of the specimens and fatigue loading.

The present study accepted the hypothesis that there is a significant difference in the effect of post length on the fracture strength, it rejected the hypothesis that there is a significant difference between the types of posts.

Some studies observed that teeth restored with cast post-and-core systems present higher fracture strength when post length is increased[10,15,17]. Otherwise, others authors[10,20] showed that increasing of post length in teeth restored with prefabricated posts and composite resin core did not increase significantly the fracture strength of endodontically treated teeth. However, post decementation has been pointed as the main cause of failure when pre-fabricated posts are used[21-23].

Not only does the material of the root canal posts affect the retention of the restorations, but also the properties of the luting agents may influence the bonding strength. This study used glass ionomer cement in accordance with the manufacturer's instructions to cement all posts. Glass ionomer cements adhere to dentin via chemical and micromechanical retention[25]. It is well know that these materials set by means of two distinct reactions[25]. The first reaction consumes all of the available water in its composition, and a second reaction occurs only when water is available from the dentin[26-27]. There is an initial contraction due to the setting reaction[28] and then cement maturation leads to a hygroscopic expansion[29]. This can result in a more intimate adaptation between cement and dentin[30], which increases resistance to displacement of the post[29]. Frictional retention is directly proportional to the contact area (the larger the contact surfaces, the better the retention). The hygroscopic expansion and larger contact areas could explain the results of this study, in which a statistically significant difference was found for post length ($p < 0.001$), with the 10-mm-long posts of both post systems requiring greater force to dislodge than 5-mm and 7.5-mm-long posts.

In addition to the contact area, closer contact between cement type and dentin is also important in order to improve the frictional retention of the post[31]. It has been demonstrated that the cementation procedure is a highly significant factor affecting the retention of cast post-and-core systems. In the present study, the cement was inserted into the canal with a lentulo spiral at low speed, which has been shown to produce significantly greater values of retention[32-35]. This can be justified by taking into account the most critical problem encountered in cementation, which is air entrapment through the liquid cement to create voids, thereby compromising the physical properties of the cement film[36]. Turner[37] (1981) suggested that those voids are responsible for the unexpected low retentive values for dowels. The lentulo spiral can ensure complete coating of the post space walls without inclusion

of air bubbles, and results in an even layer of luting cement around the post, which will result in increase of the retention in the cement-tooth interface and cement-post interface[32]. These considerations, together with hygroscopic expansion and higher contact areas produced by the cement, could explain the lack of significant difference in retention between cast post-and-cores and pre-fabricated posts when the same post length was compared in the present study.

Salvi et al.[38] (2007) showed that after 4 years of follow up, from 166 pre-fabricated posts and 82 cast post-and-cores only 4 posts lost retention, all of them were cast ones. Although the tensile strength of pre-fabricated posts and cast post-and-cores were statistically similar, the pre-fabricated posts presented higher strength, when they are restored with 5-mm and 7.5-mm-long posts. Gómez-Polo et al.[39] (2010) found no significant difference between pre-fabricated posts and cast post-and-cores after a mean follow up period of 10 years.

In conclusion, this study showed that increasing post length significantly increased the tensile strength of prefabricated posts and cast post-and-core used in endodontically treated teeth. On the other hand, significant differences were not found when comparing endodontically treated teeth restored with custom cast post-and-cores or pre-fabricated post and composite resin core with the same post length.

References

1. Torbjorner A, Fransson B. A literature review on the prosthetic treatment of structurally compromised teeth. Int J Prosthodont. 2004; 17: 369-76.
2. Stockton LW. Factors affecting retention of post systems: a literature review. J Prosthet Dent. 1999; 81: 380-5.
3. Pereira JR, de Ornelas F, Conti PC, do Valle AL. Effect of a crown ferrule on the resistance of endodontically treated teeth restored with prefabricated posts. J Prosthet Dent. 2006; 95: 50-4.
4. Pereira JR, Mendonça Neto T, Porto V de C, Pegoraro LF, Valle AL. Influence of the remaining coronal structure on the resistance of teeth with intraradicular retainer. Braz Dent J. 2005; 16: 197-201.
5. Pereira JR, Valle AL, Shiratori FK, Ghizoni JS, Melo MP. Influence of intraradicular post and crown ferrule on the fracture strength of endodontically treated teeth. Braz Dent J. 2009; 20: 297-302.
6. Zogheib LV, Pereira JR, Valle AL, Oliveira JA, Pegoraro LF. Fracture resistance of weakened roots restored with composite resin and glass fiber post. Braz Dent J. 2008; 19: 329-33.
7. Oliveira JA, Pereira JR, Valle AL, Zogheib LV. Fracture resistance of endodontically treated teeth with different heights of crown ferrule restored with prefabricated carbon fiber post and composite resin core by intermittent loading. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2008; 106: e52-7.
8. Valle AL, Pereira JR, Shiratori FK, Pegoraro LF, Bonfante G. Comparison of the fracture resistance of endodontically treated teeth restored with prefabricated post and composite resin core with different post lengths. J Appl Oral Sci. 2007; 15: 29-32.
9. Melo MP, Valle AL, Pereira JR, Bonachela WC, Pegoraro LF. Evaluation of fracture resistance of endodontically treated teeth restored with prefabricated posts and composites with varying quantities or remaining coronal tooth structure. J Appl Oral Sci. 2005; 13: 141-6.
10. Pereira JR, Valle AL, Juvencio TM, Fernandes TM, Ghizoni JS, Só MVR. Effect of post length on endodontically treated teeth: Fracture resistance. Br J Oral Sci. 2010; 9: 176-80.
11. Hammerle CH, Ungerer MC, Fantoni PC, Bragger U, Burgin W, Lang NP. Long-term analysis of biologic and technical aspects of fixed partial

dentures with cantilevers. Int J Prosthodont. 2000; 13: 409-15.

12. Panitvisai P, Messer HH. Cuspal deflection in molars in relation to endodontic and restorative procedures. J Endod. 1995; 21: 57-61.

13. Caputo AA, Standlee JP. Pins and posts-Why, when and how. Dent Clin North Am. 1976; 20: 299-311.

14. Fernandes AS, Shetty S, Coutinho I. Factors determining post selection: A literature rewiew. J Prosthet Dent. 2003; 90: 556-62.

15. Standlee JP, Caputo AA, Collard EW, Pollack MII. Analysis of stress distribution by endodontic posts. Oral Surg. 1972; 33: 952-60.

16. Leary JM, Aquilino, SA, Svare CW. An evaluation of post length within the elastic limits of dentin. J Prosthet Dent. 1987; 57: 277-81.

17. Holmes DC, Arnold AM, Leary JM. Influence of post dimensions on stress distribution in dentin. J Prosthet Dent. 1996; 75: 140-7.

18. Trabert KC, Caputo AA, Abou Rass M. Tooth fracture - A comparison of endodontic and restorative treatment. J Endodont. 1978; 4: 341-5.

19. Burns DA, Krause WR, Douglas HB, Burns DR. Stress distribution surrounding endodontic posts. J Prosthet Dent. 1990; 64: 412-8.

20. Isidor F, Brondum K, Ravnholt G. The influence of post length and crown ferrule on the resistance to cyclic loading of bovine teeth prefabricated titanium post. Int J Prosthodont. 1999; 12: 79-82.

21. Monticelli F, Grandini S, Goracci C, Ferrari M. Clinical behavior of translucent-fiber posts: a 2-year prospective study. Int J Prosthodont. 2003; 16: 593-6.

22. Ferrari M, Vichi A, Mannocci F, Mason PN. Retrospective study of the clinical performance of fiber posts. Am J Dent. 2000; 13: 9B-13B.

23. Ferrari M, Vichi A, Garcia-Godoy F. Clinical evaluation of fiber-reinforced epoxy resin posts and cast post and cores. Am J Dent. 2000; 13: 15B-8B.

24. Kvist T, Rydin E, Reit C, The relative frequency of periapical lesions in teeth with root canal –retained posts. J Endodont. 1989; 15: 578-80.

25. Young AM, Rafeeka SA, Howlett JA. FTIR investigation of monomer polymerisation and polyacid neutralisation kinetics and mechanisms in various aesthetic dental restorative materials. Biomater. 2004; 25: 823-33.

26. Yiu CK, Tay FR, King NM, Pashley DH, Sidhu SK, Neo JC, et al. Interaction of glass-ionomer cements with moist dentin. J Dent Res. 2004; 83: 283-9.

27. Yiu CK, Tay FR, King NM, Pashley DH, Carvalho RM, Carrilho MR. Interaction of resin-modified glass-ionomer cements with moist dentine. J Dent. 2004; 32: 521-30.

28. Dauvillier BS, Feilzer AJ, De Gee AJ, Davidson CL. Visco-elastic parameters of dental restorative materials during setting. J Dent Res. 2000; 79: 818-23.

29. Cury AH, Goracci C, de Lima Navarro MF, Carvalho RM, Sadek FT, Tay FR, et al. Effect of hygroscopic expansion on the push-out resistance of glass ionomer-based cements used for the luting of glass fiber posts. J Endod. 2006; 32: 537-40.

30. Huang C, Kei LH, Wei SH, Cheung GS, Tay FR, Pashley DH. The influence of hygroscopic expansion of resin-based restorative materials on artificial gap reduction. J Adhes Dent. 2002; 4: 61-71.

31. 31.Macedo VC, Faria e Silva AL, Martins LR. Effect of cement type, relining procedure, and length of cementation on pull-out bond strength of fiber posts. J Endod. 2010; 36: 1543-6.

32. Al-Omari WM, Zagibeh AM. The retention of cast metal dowels fabricated by direct and indirect techniques. J Prosthodont. 2010; 19: 58-63.

33. Reel DC, Hinton T, Riggs G, Mitchell RJ. The effect of cementation method on the retention of anatomic cast post and cores. J Prosthet Dent. 1989; 62: 162-5.

34. Fakiha Z, Al-Aujan A, Al-Shamrani S. Retention of cast post cemented with zinc phosphate cement using different cementing techniques. J Prosthodont. 2001; 10: 37-41

35. Goldestein GR, Hudis SL, Weintraub DE. Comparison of four techniques for the cementation of posts. J Prosthet Dent. 1986; 55: 209-11.

36. Assif D, Bitenski A, Pilo R, Oren E. Effect of post design on resistance to fracture of endodontically treated teeth with complete crowns. J Prosthet Dent. 1993; 69: 36-40.

37. Turner CH. Cement distribution during post cementation. J Dent. 1981; 9: 231-9.

38. Salvi, GE, Siegrist Guldener B E, Amstad T, Joss A, Lang NP. Clinical evaluation of root filled teeth restored with or without post-and-core systems in a specialist practice setting. Int Endod J. 2007; 40: 209-15.

39. Gómez-Polo M, Llidó B, Rivero A, Río J, Celemin A. A 10-year retrospective study of the survival rate of teeth restored with metal prefabricated posts versus cast metal posts and cores. J Dent. 2010; 38: 916-20.