

# Effect of increased post length due to the presence of the remaining coronal structure on the fracture strength of post-retained restorations

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**Abstract** - This study evaluated the effects of the remaining coronal tissue and post type on the fracture strength of incisors. Sixty human maxillary central incisors were sectioned at the cemento-enamel junction or at 2 mm above this junction. The roots received cast cores and posts, fibre posts, or relined fibre posts ( $n = 10$  each). A compressive load was applied over the cores until fracture. In the absence of coronal structure, the fracture strength did not differ among the post types evaluated. In the presence of remaining coronal structure, the fracture strength was higher in specimens with cast cores and posts.

**KEYWORDS:** Compressive strength; Post and core technique; Dental restoration.

## INTRODUCTION

Despite the evolution of restorative materials, the restoration of endodontically treated teeth remains challenging for clinicians. For several years, cast post and core techniques have been used to restore teeth with insufficient crowns remaining to retain restorations.<sup>1-3</sup> However, metallic posts can compromise the aesthetics of restorations when used in anterior teeth, and the laboratory requirements of cast post and core techniques increase the cost and duration of treatment. Thus, the use of fibre-reinforced resin posts for the restoration of endodontically treated teeth has increased recently.<sup>4</sup> The fibre posts present a lower elastic modulus than do metallic posts, resulting in reduced incidence of root fracture.<sup>5-7</sup> However, a recent study showed that this reduced incidence is due to a greater chance of post/core, rather than root, fracture.<sup>8</sup> Post debonding and post and/or core fracture are more common causes of failure when this type of post is used.<sup>4,9</sup> Despite the advantages of this post type, the mismatch between the diameters of the post space and the fibre post remains a clinical problem.<sup>10</sup> The relining of fibre posts with composite resin has been advocated to improve their adaptation to root walls and reduce the thickness of resin cement.<sup>11-14</sup>

Independent of the post type, the presence of the remaining coronal tooth structure is associated with the improved longevity of restorations.<sup>4,9,15</sup> However, most studies evaluating the effects of ferrule on the fracture strength of restorations have used posts with standardised lengths in the presence and absence of ferrule.<sup>2,16,17</sup> In this experimental design, the favourable effect of increased post length can obscure the true effect of the ferrule. Thus, the

aim of this study was to evaluate the effect of post length due to the presence of the remaining coronal tooth structure on post/root fracture strength. The tested hypothesis was that the length of the cemented posts would alter the fracture strength.

## MATERIALS AND METHODS

Sixty human maxillary central incisors that had been extracted for periodontal reasons were used in this study. The teeth had similar dimensions and straight roots, and teeth with carious lesions or cracks were excluded. Thirty teeth were sectioned 2 mm above the cemento-enamel junction (CEJ). The axial walls of the remaining coronal portions were prepared with an ogival diamond bur #3215 to obtain a chamfer finish line. Preparation was performed at high speed under water cooling. The other 30 incisors were sectioned at the CEJ with no coronal remnant. A stepback preparation technique was used for endodontic treatment, and the root canals were filled with gutta-percha cones using the lateral condensation technique and Sealer-26 resin sealer. The specimens were stored at 100% humidity for at least 72 h to allow the resin sealer to set.

After the storage period, the gutta-percha was removed to a depth of 10 mm with a hot Rhein instrument, followed by the use of a Peeso #2 bur at the same depth. The #3 bur of the White Post DC fibre post system (FGM, Joinville, Brazil) was used to standardise the post holes. The White Post used was a glass fibre-reinforced epoxy post, cone shaped, with diameters varying from 1.25 to 2.0 mm. To simulate the periodontal ligament, the external surfaces of root remnants were dipped in melted wax to 3 mm below the CEJ. The wax-covered roots were then placed in acrylic resin cylinders. After resin polymerisation, the roots were removed from the cylinders and the wax was removed from the root surfaces to create spaces in the resin cylinders. The polyether impression material Impregum F was mixed and placed in these spaces. The teeth were reinserted into the cylinders and excess material was removed with a scalpel.

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**Table 1.** Composition of the materials used for fibre post luting.

Material	Classification	Composition*
Scotchbond Multipurpose	Adhesive system	Adhesive: Bisphenol A-diglycidyl Ether Dimethacrylate, Hydroxyethyl Methacrylate, Triphenylantimony.
Multilink	Conventional adhesive luting system	Primer A: Initiators, water Primer B: Phosphonic acid acrylate, Hydroxyethyl methacrylate, Methacrylate mod. polyacrylic acid, Stabilisers. Adhesive: 3-Methacryloxypropyltrimethoxysilane, Aethyl alcohol, Distilled water. Cement: Dimethacrylate, Hydroxyethyl Methacrylate, Barium glass filler and silicon dioxide filler, Ytterbiumtrifluoride, Catalysts, stabilisers, Pigments.

\*As provided by the manufacturers.

**Table 2.** Means (standard deviation) of fracture strength in N.

Type of post	Coronal remaining	
	Absent	Present
Cast post and core	335.5 (228.2) <sup>Ba</sup>	773.1 (407.3) <sup>Aa</sup>
Relined fibre post	345.2 (128.3) <sup>Aa</sup>	379.0 (107.2) <sup>Ab</sup>
Fibre post	179.9 (39.7) <sup>Aa</sup>	213.5 (41.5) <sup>Ab</sup>

Distinct letters (uppercase for line, lowercase for columns) indicate significant difference ( $\alpha = 0.05$ ).

Specimens with and without remaining coronal structure received cast cores and posts, fibre posts (#3 White Post DC), and relined fibre posts ( $n = 10$  each).

To permit the fabrication of cast cores and posts, root canal impressions were made with prefabricated pins and the self-curing acrylic resin Duralay. The cores were built up with acrylic resin (5-mm height) and a standardised notch was created across the palatal surface of each core 3 mm from the incisal edge for load application in mechanical tests. The posts and cores were then cast in a nickel-chromium alloy. The cast cores and posts were cemented with Multilink resin cement in accordance with the manufacturer's instructions. Polyvinylsiloxane impressions of the cast cores were taken to permit the standardisation of resin cores in specimens that received fibre posts. The impressions were poured with Type IV stone, and acetone matrices were fabricated.

The post surfaces of the 20 specimens that received fibre posts were cleaned with ethanol and dried with an air stream. The surfaces were then silanised and the fibre posts were cemented with Multilink resin cement. In 20 additional specimens, the fibre posts were relined with composite resin before cementation. For this purpose, the canal walls were lubricated with hydrosoluble gel, followed by the insertion of Filtek Z-350 composite into the root canals. Scotchbond Multipurpose adhesive was applied to the silanated posts and light-cured. The fibre posts were inserted into the root canals and the resin composite was light cured for 20 s. The relined fibre posts were then removed, and the resin composite was light cured for another 40 s. The lubricant gel was removed from the root canals with copious rinsing before cementation with Multilink. The cores of specimens that received relined or non-relined fibre posts were built up incrementally with Filtek Z-350 composite resin. Details

of materials used for fibre post cementation are displayed at Table 1. Before light activation of the final resin application, matrices were obtained by the impression of a cast core and positioned to standardise the cores. All light curing procedures were performed with a light emitting diode curing unit (Radii Cal; SDI, Bayswater, Victoria, Australia) with 600-mW/cm<sup>2</sup> irradiance.

Specimens were positioned in a customised apparatus that allowed the insertion of a metal knife-blade tip into the notches on the palatal surfaces of the cores at a 45° angle with respect to the long axis of the tooth. The specimens were submitted to tangential compressive loading in a universal testing machine at a rate of 0.5 mm/min until fracture. Data (in Newtons) were submitted to two-way analysis of variance (ANOVA; presence of remaining coronal structure × post type), followed by Tukey's test ( $\alpha = 0.05$ ).

## RESULTS

ANOVA showed that the presence of remaining coronal structure ( $P < 0.001$ ), post type ( $P = 0.002$ ), and the interaction between these factors ( $P = 0.003$ ) had significant effects on fracture strength. The results of Tukey's tests are displayed in Table 2. In the absence of remaining coronal structure, no difference was observed among the post types. Among the specimens with remaining coronal structure, the fracture strength was highest in those with cast cores and posts and did not differ between the other post types.

## DISCUSSION

The preservation of coronal structure has been advocated to improve the longevity of post-retained restorations.<sup>4,9,15</sup> The maintenance of cervical crown tissue permits the restoration to surround the parallel dentin walls and extend coronally, creating a protective effect on the tooth structure.<sup>2</sup> This "ferrule effect" is due to the reduction of stress within the tooth. However, the presence of remaining coronal structure also increases the required length of a post cemented into the root canal, which may contribute to the benefit attributed to the ferrule effect. The results of the present study showed that the presence of the remaining coronal structure improved the fracture strength only when cast cores and posts were used but had no effect with relined or non-relined fibre posts. Thus, the null hypothesis was rejected. A previous study evaluating the length of post cementation yielded similar results.<sup>18</sup>

Most studies evaluating the effect of remaining coronal structure on fracture strength have used metallic<sup>2,17</sup> or ceramic<sup>2,16</sup> crowns cemented over cores. In this design, the load is applied over the palatine face of the crown, similar to the clinical condition. The stress created by load application is partially generated in coronal dentin (ferrule effect), reducing stress in the root canal.<sup>2</sup> In contrast, the compressive load was applied directly over the core in the present study. Considering the absence of the ferrule effect in this experimental design due to the absence of a full crown, only the effect of a difference in post length can explain the results.

In the present study, the lengths of the posts placed in the root canals ranged from 10 mm (no remaining coronal structure) to 12 mm. The strain values of cast posts have been demonstrated to increase with decreasing post length.<sup>18</sup> Thus, reduced strain in the presence of coronal structure improves fracture strength, explaining the results observed in specimens with cast cores and posts in the present study. The high elastic modulus of cast posts (approximately 188.4 GPa for nickel-chromium posts)<sup>19</sup> helps explain this behaviour. On the other hand, the absence of such an effect in specimens with fibre posts can be explained by the similar elastic moduli of these posts (between 10 and 30 GPa)<sup>20</sup>, composite resin (approximately 15 GPa)<sup>21</sup>, and dentin (approximately 18 GPa).<sup>22</sup> Interestingly, fibre posts can generate high levels of stress on the root structure, but the risk of root fracture is lower than with core and fibre posts.<sup>8</sup> Considering that fracture of fibre post-retained restorations occurs commonly on the post or core (resin composite), the length of the post in the root canal can reasonably be assumed to have a limited effect on the final fracture strength.

Proper bonding of fibre posts to root canal walls has been demonstrated to reduce the risk of fracture.<sup>8</sup> Relining was used in this study to increase the adaptation between the fibre posts and root walls. Even using the bur provided by the manufacturer, the cervical portion of the post hole remains larger than the diameter of the post. Greater adaptation increases sustained pressure during cementation and improves bond strength.<sup>13,19</sup> Thus, relined fibre posts could be expected to have greater fracture strength than non-relined posts. However, no difference between these post types was observed in the present study. This finding may be explained by the use of unflared root canals. Most studies demonstrating that relining improved bond strength have used flared root canals.<sup>13,23,24</sup> Flaring increases the discrepancy between the post and root canal, likely leading to a more pronounced positive effect of relining. Thus, the use of relined fibre posts appears to effectively increase the fracture strength in flared root canals, but further studies are needed to confirm this statement.

However, it is important to emphasise that the highest fracture strength values were found in cast cores and posts in the presence of remaining coronal tooth structure. Several clinical studies have demonstrated a high rate of longevity for cast post-retained restorations, mainly in the presence of remaining coronal structure.<sup>2, 25,26</sup> Furthermore, the cast post did not show similar results to the relined fibre posts and showed higher fracture strengths than fibre posts when the remaining coronal structure was absent. However, the outcomes of the present study must be carefully evaluated. Some laboratory studies have demonstrated that metal

posts are generally associated with higher root fracture incidence than fibre posts.<sup>27</sup> One limitation of the present study was that it did not evaluate the mode of fracture; however, clinical studies did not confirm this increased root fracture incidence for metal posts.<sup>2, 25,26</sup>

## CONCLUSION

Within the limitations of the current study, the following conclusions can be drawn:

The presence of remaining coronal structure improved fracture strength only when cast cores and posts were used; the fracture strength was higher in these specimens than in those with relined or non-relined fibre posts.

Fracture strength did not differ among post types in the absence of coronal tooth structure.

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