

## Comparison of fracture resistance of bonded glass fiber posts at different lengths

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**ABSTRACT: Purpose:** To evaluate *in vitro* the fracture resistance of quartz fiber posts for three different dowel lengths. **Methods:** 30 single-rooted human premolars with similar root length and diameter were endodontically treated and randomly divided into three experimental groups (n=10) according to the post space depth created: (1) 5 mm; (2) 7 mm; (3) 9 mm. Quartz fiber posts (Endo Light post) were cemented using a dual cured resin cement with its adhesive system (Prime&Bond NT + Fluorocore 2). After 24 hours, specimens were embedded in acrylic resin and loaded under continuous compressive force at the extruding coronal part of the post (45-degree angle) to the long tooth axis (cross-head speed: 0.75 mm/minute). Forces at fracture (Newtons) were recorded. One-way ANOVA and Tukey tests were used for the statistical analysis (P< 0.05). **Results:** Mean strength values (SD) were: (1) 40.52 (3.14); (2) 41.68 (5.31); (3) 44.88 (6.77), respectively. No statistically significant differences were found among the groups. (*Am J Dent* 2010;23:000-000).

**CLINICAL SIGNIFICANCE:** Within the limitations of the study, increasing post lengthwise does not provide additional resistance to fracture. A more conservative approach could be clinically advisable when dentists choose to restore endodontically treated teeth with fiber posts.

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### Introduction

Different post systems have been proposed over the years, from the early cast metallic posts to the pre-fabricated metallic posts or the more recently introduced, translucent fiber posts. Fiber-reinforced composite (FRC) root canal posts have been introduced as an alternative to conventional materials.<sup>1,2</sup> The biomechanical properties of FRC posts have been reported to be close to that of dentin.<sup>3-5</sup> Clinical prospective and retrospective studies on the use of fiber posts have reported encouraging results.<sup>6-8</sup> Fiber posts consist of a resin matrix enveloping quartz or glass fibers.<sup>9</sup> The microstructure of each post is based on the diameter and density of the individual fibers and on the quality of adhesion between the fibers and resin matrix.<sup>9</sup> Fiber posts are made in pre-shaped molds in which fibers are pre-stressed and the resin filler is injected under pressure to fill in the spaces between the fibers, giving them solid cohesion. Usually the resin matrix is made of epoxy resin or its derivatives. Important characteristics of fiber posts include a modulus of elasticity similar to that of dentin<sup>10</sup> and the combined use of adhesive resin cements represents an additional chance to dissipate stresses over all of the root, thus avoiding undesirable premature failure due to root fracture.<sup>11,12</sup>

The growing esthetic demands of patients has made the fiber post/resin cement combination an accepted restorative procedure, creating the basis for a minimal intervention technique.

Different factors may influence the clinical outcome of the post-restored tooth, such as post design, length,<sup>13</sup>

diameter,<sup>14</sup> and root canal configuration. However, post length remains one of the most controversial topics.

Several guidelines have been suggested in order to establish the more advantageous dowel length. According to the literature, it should be (1) equal to half of the root length,<sup>15</sup> (2) equal to two thirds of the root length,<sup>16</sup> (3) equal to the length of the clinical crown;<sup>17-19</sup> and (4) the post should extend as long as possible, leaving 3 mm of gutta-percha to provide a reliable apical seal.<sup>20</sup> These statements referred to cast metal posts, which have an elastic moduli different from that of dentin or fiber posts and only frictional retention in the root canal.<sup>21</sup> The most common criteria reported in the literature recommend a post length equal to  $\frac{3}{4}$  of root canal length or at least equal to the length of the crown<sup>22</sup> leaving at least 4 mm of gutta-percha. Reporting these criteria to fiber posts could be considered erroneous, due to the different mechanical behavior of the dowel itself.

The role of the fiber post as core retainer has been shown,<sup>23</sup> while its contribution to root strengthening has not been proven. Obviously, fiber post length has an effect on the amount of root dentin to be removed, potentially weakening the root.<sup>24</sup> The deeper the post insertion is, the more difficult it is to obtain a reliable bond, due to both anatomic reasons (*i.e.* reduction of dentin tubules for  $\text{mm}^2$  in the apical direction) and technical difficulties (*i.e.* limited cleansing and accumulation of canal walls debris in the apical third).<sup>25</sup>

This study aimed to estimate the fracture resistance of dowels cemented at different levels in post space. The force was applied entirely on the post, so as to avoid any external influence (coronal tooth structure or small ferrules) due to the core material and presence of dentin walls.

The null hypothesis tested was that fiber posts inserted at three different lengths in root canal do not differ in terms of fracture strength.

## Materials and Methods

Thirty caries-free, single rooted human premolars of similar root diameter and length were selected for the study after informed consent had been obtained under a protocol reviewed and approved by the institutional review board of the University of Siena (Italy). The coronal portion of each tooth was sectioned perpendicular to the long axis, 1 mm above the CEJ using a low-speed diamond saw under copious water-cooling (Isomet<sup>a</sup>).

Working length was established at 1 mm from the root apex. Cleaning and shaping of the root canal were performed with rotator Ni-Ti files to size #40 (0.04)<sup>b</sup> following the crown-down technique. Irrigation with 5.25% sodium hypochlorite was performed between the instrumentations. Gutta-percha cones<sup>b</sup> were used for filling the canals and cemented with a resin sealer AH Plus Jet<sup>c</sup> referring to the warm vertical compaction technique. A coronal seal was created with a glass-ionomer cement (Fuji II<sup>d</sup>) and the specimens stored in a laboratory oven at 37°C and 100% relative humidity.

After 24 hours, the coronal seal was abraded by means of #240 SiC paper under water cooling. The gutta-percha was removed leaving a 5 mm long apical seal and post spaces were prepared with a universal drill. Each root was randomly assigned to one experimental group, according to the depth

of the post-space created (n=10): (1) 5 mm; (2) 7 mm; (3) 9 mm.

Translucent quartz fiber posts (Endo Light-Post #3<sup>e</sup>) consisting of unidirectional, pre-tensed fibers bound in a translucent epoxy resin matrix, were used. Each post was tried in the root canal and cut to the adequate length. The free post length extruding out the root was standardized to 4.8 mm. Prior cementation, a pre-hydrolyzed silane coupling agent (Monobond S<sup>f</sup>) was applied with a microbrush on the post surface for 60 seconds. A light-cured, self-priming adhesive Prime & Bond NT<sup>c</sup> was applied into the root canal with a microbrush for 20 seconds, gently air-dried, and the excess was removed using paper points.

The bonding was polymerized with a conventional quartz-tungsten-halogen light (Optilux 401<sup>g</sup>). Fluorocore 2<sup>c</sup> core build-up material was used for fiber post luting. Base and catalyst (1:1) were mixed for 30 seconds, and then the material was applied on the post and the post was seated immediately into the canal and sustained under finger pressure. Excess material extruding out of the root was removed with a spatula. After the first 7 minutes of auto-cure, the material was light-cured using a conventional quartz-tungsten-halogen light (750 mW/cm<sup>2</sup>) for 40 seconds by placing the light tip on the coronal end of the post. The specimens were stored for 24 hours in a laboratory stove at 37° and 100% relative humidity. At the end of the storage period, each root was embedded in a self-polymerizing acrylic resin (Pro Base Cold<sup>h</sup>) for half of the root length, with the long axis sloped at 45° to the base of the resin block. During such procedure, specimens were continuously irrigated with water to avoid overheating due to resin polymerization. Before performing mechanical test, samples were stored for 24 hours at 37°C and 100% relative humidity.

Each sample was then mounted on a universal testing machine.<sup>h</sup> A controlled compressive load (cross-head speed: 0.75 mm/minute) was applied by means of a stainless steel stylus (Ø 1 mm) at the coronal end of the post extruding out the root (Figure). A software (Digimax Plus<sup>i</sup>) connected to the loading machine registered the maximum breaking load that was expressed in Newton (N).

*Statistical analysis* - The normal and equal distribution of the data were first checked with the Levene's and the Kolmogorov-Smirnoff tests respectively. A one-way ANOVA was performed for the statistical analysis, with the post as factor and the post length as variable (P< 0.05). Tukey test was used for *post hoc* comparisons. Calculations were handled by the SPSS software.<sup>j</sup>

## **Results**

The means (SD) of the failure forces (N) for all groups are shown in the Table, and were respectively: (1) 40.52 (3.14); (2) 41.68 (5.31); (3) 44.88 (6.77). The fracture resistance of fiber posts was not influenced by the different dowel length (5 mm, 7 mm and 9 mm), as revealed by the statistical analysis.

## **Discussion**

This study's primary aim was to evaluate different post lengths' effect on fracture resistance of a glass fiber post system.

In this laboratory study, teeth were carefully selected for standardized size. This is an important variation in the resistance to fracture of the specimens.<sup>26</sup>

The mean value of post fracture showed that the deeper post length and the higher resistance to fracture was in Group 3, with the 9 mm post length, (44.88 N), but this procedure required removal of large amounts of sound tissue. The loss of dentin is in fact the primary cause for fracture susceptibility in endodontically-treated teeth.<sup>27</sup>

Group 1 showed the lower resistance to fracture (40.52 N), using the more conservative post space preparation; it has been demonstrated that the greater the post length, the better the retention and stress distribution.<sup>28</sup> This is a very controversial topic because other studies have suggested that a shorter post length may be used without loss of retention.<sup>29-31</sup>

In Group 2 (the post luted at 7 mm in the root canal), the fracture resistance of the post was 41.68 N, the medium value of the three experimental groups.

The null hypothesis had to be accepted as no statistically significant differences were found among the three experimental groups.

Concerning root fracture, there is consensus that a post that is too short or too long places the tooth at risk.<sup>32-34</sup> Increasing the thickness of the post will make it stronger, but less tooth structure remains, and the combined effect may well be a reduction of the strength of the assembly.<sup>32,33</sup> The situation is less obvious when the stiffness of the post is considered. The goal is to reduce the stresses in the root dentin to a minimum, but some researchers support the view that a post of high stiffness leads to a more even distribution of the stresses,<sup>32</sup> while others maintain that an endodontic post of low stiffness should be preferred.<sup>35,36</sup>

A consideration of the root size and length is important, because improper post space preparation and use of large-diameter posts present the risk of apical or lateral perforation.

One of the disadvantages associated with the use of preformed posts is the need to adapt the root canal to the shape and size of the post to be used. The adaptation of the canal to the post requires the sacrifice of sound dentin tissue which conflicts with one of the universally accepted concepts in the restoration of endodontically treated teeth: prognosis improves proportionally to the amount of sound tooth structure present, regardless of the type of restoration chosen.<sup>37</sup> The loss of dentin is in fact the primary cause for fracture susceptibility in endodontically treated teeth.<sup>37-39</sup>

In accordance with previous studies, dental tissue should be conserved in order to predict the clinical success of a post restoration on a healthy tooth.<sup>40,41</sup> A recent study<sup>42</sup> was designed to obtain a bio-faithful model of the maxillary incisor system and to assess the effect of glass fiber post lengths using finite element analysis, and the overall system's strain pattern did not appear to be influenced by post length.

To date, there is still no agreement about which post length should be preferred when restoring endodontically treated teeth. From one side, diminishing post length

insertion would mean preservation of root dentin. On the other hand, it would provide less retention to the post itself. After endodontic treatment and post space preparation the amount of remaining tooth structure has great value for the prognosis of the restoration.<sup>23,43,44</sup> Adhesively luted fiber posts is considered a conservative approach for the restoration of devitalized teeth when compared to cast metal posts.<sup>45</sup> In any case, over-preparation of the post space and the use of outsized posts do not offer supplementary reinforcement to the post/tooth complex, but can only decrease the fracture resistance of post restored teeth or affect the apical seal.<sup>40</sup> *In vitro* studies<sup>40,41</sup> demonstrated that the amount of residual tooth structure, rather than the dowel itself, is important to ensure strength to endodontically treated teeth while the role of fiber posts as core-retainer has been universally accepted.<sup>23</sup>

Contrary to cast metal post, decreasing fiber post length insertion does not modify its mechanical behavior, probably because of the similar mechanical properties between fiber post and dentin. The retention of a fiber post could be increased thanks to the adhesive mechanism that is established with the resin cement, allowing the clinicians to be more conservative. Moreover, the reduced post length could beneficially influence the light polymerization, when a light-polymerized material is used for fiber post cementation. The deeper the post space depth, the easier it would be for the light polymerization to reach the deep areas.<sup>46</sup> The fracture mode of the samples analyzed was not taken into consideration, as many factors may influence the modality, such as presence of residual coronal walls, core build-up and/or load direction. Further studies should evaluate if the presence of a ferrule would change the results obtained in the present investigation.

- a. Buehler, Lake Bluff, IL, USA.
- b. Tulsa Dental Products, Tulsa, OK, USA.
- c. Dentsply DeTrey, Konstanz, Germany.
- d. GC Corporation, Tokyo, Japan.
- e. Bisco, Schaumburg, IL, USA.
- f. Ivoclar Vivadent, Schaan, Liechtenstein.
- g. Kerr, Danbury, CT, USA.
- h. Instron Corp, Canton, MA, USA.
- i. Digimax Plus Controls srl, Cernusco s/n, Italy.
- j. SPSS Inc., Chicago, IL, USA.

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Figure. Example of a sample mounted on the loading machine and prepared for the fracture test. The tooth is oriented such as the load applied by means of the metallic stylus would have a 45-degree direction.

Table. Mean (SD) of the strength values (N) recorded for fiber posts cemented at three different lengths in post space. Same letters mean indicate no statistically significant differences among the groups ( $P > 0.05$ ).

Experimental groups	Mean (SD)	No. of specimens
5 mm post length	40.52 (3.14) <sup>a</sup>	10
7 mm post length	41.68 (5.31) <sup>a</sup>	10
9 mm post length	44.88 (6.77) <sup>a</sup>	10