Evaluation of the Flexural Strength of Carbon Fiber-, Quartz Fiber-, and Glass Fiber-Based Posts

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Abstract

This study investigated the flexural strength of eight fiber posts (one carbon fiber, one carbon/quartz fiber, one opaque quartz fiber, two translucent quartz fiber, and three glass fiber posts). Eighty fiber posts were used and divided into eight groups ($n = 10$): G1: C-POST (Bisco); G2: ÆSTHETI-POST (Bisco); G3: ÆSTHETI-PLUS (Bisco); G4: LIGHT-POST (Bisco); G5: D.T. LIGHT-POST (Bisco); G6: PARAPOST WHITE (Coltene); G7: FIBERKOR (Pentron); G8: REFORPOST (Angelus). All of the samples were tested using the three-point bending test. The averages obtained were submitted to the ANOVA and to Tukey's test ($p < 0.05$). The mean values (MPa) of the groups ÆSTHETI-POST—carbon/quartz fiber post (Bisco) and ÆSTHETI-PLUS—quartz fiber post (Bisco) were statistically similar and higher than the mean values of the other groups. The mean values of the groups C-POST—carbon fiber post (Bisco), LIGHT-POST—translucent quartz fiber post (Bisco), D.T. LIGHT-POST—double tapered translucent quartz fiber post (Bisco), PARAPOST WHITE—glass fiber post (Coltene) and FIBREKOR—-glass fiber post (Pentron) were similar and higher than the group REFORPOST—glass fiber post (Angelus).

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Failures of restorations with intraradicular retention may occur because of postfracture, loss of retention, crown or root fracture, the latter regarded as the most severe because it leads to the need of tooth extraction. The utilization of cast metallic posts yields a root fracture index of approximately 2 to 4% (1), which has been assigned to stress concentration (2, 3). For that reason, fiber posts were developed that presented an elasticity modulus (E) closer to that of dentin (post = 20 GPa; dentin = 18 GPa) when compared to cast posts and prefabricated metallic (E = 200 GPa) and ceramic posts (E = 150 GPa), thereby allowing absorption and uniform distribution of stresses to the remaining root structure instead of concentrating them (2–8).

A carbon fiber post (Composipost, RTD, St. Egreve, France) was initially designed (9), followed by quartz fiber posts and glass fiber posts. These posts were enhanced to compensate for certain esthetic limitations of the carbon fiber posts, because all of these posts present similar characteristics from a mechanical standpoint.

Thanks to this rapid evolution, several types of fiber posts are currently available, and their mechanical properties must be taken into account when making a clinical decision. Two of the main clinical requirements of root canal posts are a high flexural strength (10) and an elasticity modulus close to that of dentin (11). When a fiber post is excessively flexible, the force applied on the interface between post, resin and dentin may lead to restoration fracture (12).

Therefore, the aim of this study was to evaluate the flexural strength of eight types of fiber posts, by means of the three-point bending test.

Materials and Methods

This study evaluated eight different types of fiber posts. The materials employed are listed below:

Group 1: C-POST—carbon fiber post (Bisco, Schaumburg, IL);
Group 2: ÆSTHETI-POST—carbon and quartz fiber post (Bisco);
Group 3: ÆSTHETI-PLUS—opaque quartz fiber post (Bisco);
Group 4: LIGHT-POST—translucent quartz fiber post (Bisco);
Group 5: D.T. LIGHT-POST—translucent quartz fiber post (Bisco);
Group 6: PARAPOST WHITE—glass fiber post (Coltene, Cuyahoga Falls, OH);
Group 7: FIBREKOR—glass fiber post (J Pentron, Wallingford, CT);
Group 8: REFORPOST—glass fiber post (Angelus, Londrina, PR, BR)

The three-point bending test (span 6.0 mm, crosshead speed 1.0 mm/min) was used to measure the flexure strength of fiber reinforced composite post specimens. All posts were tested with a material testing machine (DL-1000, EMIC, São José dos Pinhais, PR, Brazil).

Ten posts ($n = 10$) were used for each experimental group. The diameter of each post was measured with a digital caliper with 0.01-mm accuracy (Mitutoyo, Tokyo, Japan) before test accomplishment.

The fracture load of post specimens was measured and the flexural strength (σ) was obtained by the following formula (12, 13): $\sigma = 8FL/\pi.d^3$, where F is the applied load at the highest point of the curve (kgf), L is the span length (6 mm), and d is the diameter of the specimens (mm).

The values in kgf/mm^2 obtained using the formula were transformed into MPa and submitted to an ANOVA ($\alpha = .05$) and to the Tukey test.

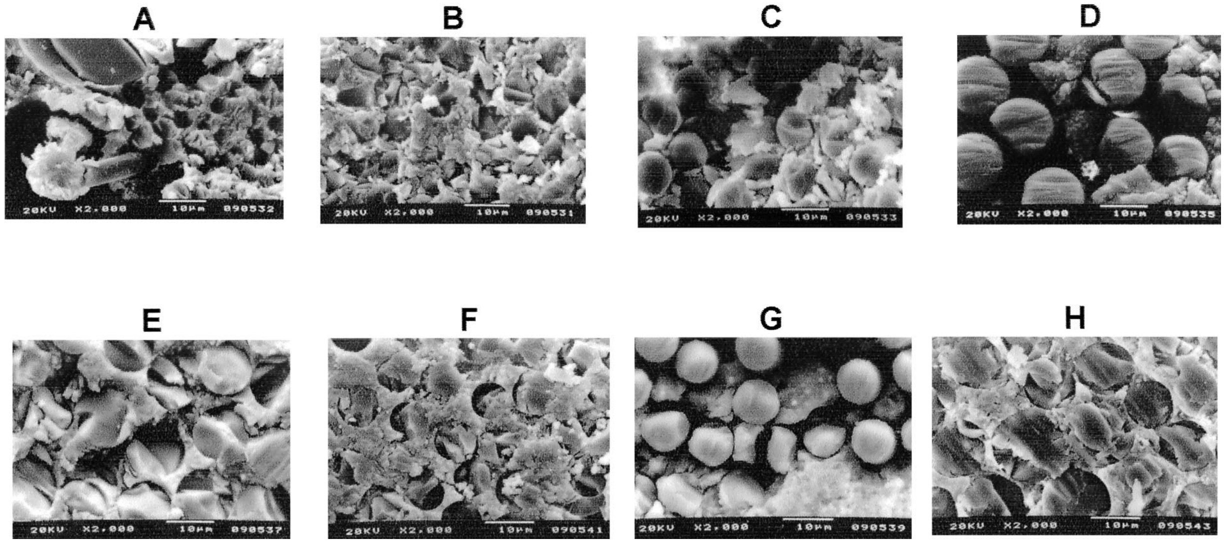

Figure 1. Transversal section of the evaluated posts (SEM, ×2000): (A) C-Post; (B) Æstheti Post; (C) Æstheti Plus; (D) Light Post; (E) D.T. Light Post; (F) Parapost Fiber White; (G) FibreKor; (H) Reforpost.

TABLE 1. Flexural strength of fiber posts

Fiber post	Strength (MPa)*
G1—C POST	616.3 ± 24.8^{b,c}
G2—ÆSTHETI-POST	677.4 ± 18.3^{a}
G3—ÆSTHETI-PLUS	666.2 ± 18.1^{a,b}
G4—LIGHT-POST	607.2 ± 19.5^{c}
G5—D.T. LIGHT-POST	608.7 ± 69.5^{c}
G6—PARAPOST WHITE	585.2 ± 24.2^{c}
G7—FIBREKOR	562.3 ± 59.6^{c}
G8—REFORPOST	433.8 ± 46.4^{d}

* Different superscript letters mean statistical difference ($p < 0.05$).

Two untested posts from each group were sectioned perpendicularly to their long axis, at approximately their halfway point. Afterwards, post samples were sputter-coated with gold palladium for 3 min in a Hummer II Sputter Coater (21020, Technics Inc., Alexandria, VA) at a current of 10 mA and a vacuum of 130 mTorr, and the surface topography was examined using a scanning electron microscope (JSM 6400, Jeol Ltd., Tokyo, Japan) (×2000). The purpose of this topographic analysis was to illustrate the characteristics of the posts (fibers and matrix).

Results

Statistical analysis of the outcomes was conducted by means of analysis of variance and the post factor was significant ($p < 0.001$).

The critical value for comparison revealed that G2 (677.4 ± 18.3) and G3 (666.2 ± 18.1) presented the highest flexural strength values. G1 (616.3 ± 24.8) and G3 (666.2 ± 18.1) presented similar strengths. G1 (616.3 ± 24.8), G4 (607.2 ± 19.5), G5 (608.7 ± 69.5), G6 (585.2 ± 24.2), and G7 (562.3 ± 59.6) were statistically similar. G8 (433.8 ± 46.4) revealed the lowest flexural strength value compared to the other groups (Table 1).

The SEM images of the fractured samples are presented in this section (Fig. 1). However, they will be described in the Discussion section.

Discussion

The compositional differences of the fibers may not play any role in determining different flexure strength values, since all of them have about the same elastic modulus (14). This could be observed in the present study, which revealed that just two out of four quartz fiber posts presented higher flexural strength in the analyses. Thus, other aspects concerning the composition of these posts, such as integrity, size, density, and distribution of the fibers and the nature of the bond between the matrix and the fibers may be the determining factors for different flexure strength values (14).

One of the most important chemical factors that may influence the post strength concerns the bonding process between the fibers and the resinous matrix. The mechanical characteristics and the performance of the composite resins were greatly improved after the bond between the inorganic filler and the organic matrix were enhanced (15). Fiber-reinforced epoxy-based posts are very similar to composite resins in one aspect: a layer of silane is applied to the inorganic fillers to provide a better chemical bond for the organic matrix (16, 17).

Even though the scanning electron microscopy analysis is just illustrative, analysis of Fig. 1 demonstrates that the eight posts analyzed displayed some differences. The cross section density varies between the post systems. The C-Post fibers are smaller in diameter and have a higher packing density. The Aestheti plus and Aestheti post fibers had a similar diameter and density. To compare the morphological aspects of the posts with the obtained values of flexural resistance, many factors have to be considered: the presence of empty spaces and bubbles; fiber morphology; characteristics of the matrix; concentration of fibers. However, the methodology of the present study does not allow the observations of any of these factors.

Considering this evidence, the type of resinous matrix and the fabrication process used to promote chemical bonding between fiber and resin may possibly be the most important factors for the fiber post strength. Much of this information is kept under industrial secret.

The Aesthesi-Plus and Light-Post posts are made of the same type of quartz fiber in similar concentrations (62% and 60%, respectively), with the difference between these posts being the type of resin matrix that surrounds the fibers (18), which allows the assumption that the best performance of the opaque post might be a result of the properties of the matrix. The carbon fiber post (C-Post) presented statistically similar outcomes when compared to the Aestheti-Plus group. Despite the differences in the type of fiber that constitutes this material, the concentration and type of epoxy resin that joins the fibers are similar

(36% and 40%, respectively) (18), allowing for similar flexural strength results.

The glass fiber posts (FibreKor and Reforpost) have a BIS-GMA-based resin matrix (19, 20). However, when the flexural strength values of these posts were analyzed, it was possible to observe that Reforpost presented less strength than FibreKor. These results may be explained because of two factors: (a) lesser strength of the resin matrix of Reforpost; (b) deficient bonding between the fiber and the resin matrix of this post.

Mannocci et al. (12) evaluated the flexural strength of five types of fiber posts (Composipost, Æstheti-plus, Carbotech, Light post and Snowpost) after storage under three different conditions: dry storage; cementation on bovine teeth, sealing with composite resin and water storage for 1 yr; and water storage for 1 yr. The authors did not find any statistically significant difference among the posts submitted to dry storage and those stored in bovine teeth, thereby demonstrating that, provided that they are properly cemented and sealed with composite resin, the post will be clinically protected from contact with the oral fluids and its flexural strength will not be impaired. For that reason, the posts analyzed were not submitted to any type of storage.

The results achieved allow for the suggestion that these materials would present a better response to the masticator forces if the superiority displayed on the direct load application on the post was considered. Therefore, in vitro studies for evaluation of the fracture strength of teeth restored with fiber posts and resin materials, as well as clinical evaluations, should be conducted to corroborate the choice of the best materials and restorative techniques.

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