# Adhesion Between Prefabricated Fiber-reinforced Posts and Different Composite Resin Cores: A Microtensile Bond Strength Evaluation

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**Purpose:** The aim of this study was to evaluate the bond strengths between various resin composites used as core materials (Multicore Flow, Ivoclar-Vivadent; Tetric Flow, Ivoclar-Vivadent; Filtek Flow, 3M-ESPE; Tetric Ceram, Ivoclar-Vivadent; Filtek Z250, 3M-ESPE), and an FRC post (FRC Postec Plus, Ivoclar-Vivadent) by means of the microtensile nontrimming technique.

**Materials and Methods:** Five experimental groups were used. For the microtensile nontrimming technique, 45 to 50 beam-shaped specimens per group were obtained from cylinders of core material, which had been built up around the post by progressively adding small increments of composite resin. Each specimen was loaded in tension until failure at either one of the two post/core interfaces present in each stick. The differences in interfacial bond strength among the groups were tested for statistical significance with the one-way ANOVA test, followed by the Dunnett test for post-hoc comparisons.

**Results:** The measured bond strengths in MPa were $17.29 \pm 6.02$ for FRC+MultiCore Flow, $16.37 \pm 6.92$ for FRC+Tetric Flow, $13.14 \pm 5.35$ for FRC + Filtek Flow, $12.38 \pm 4.34$ for FRC + Tetric Ceram, and $10.75 \pm 5.43$ for FRC + Filtek Z250. The statistical analysis revealed that MultiCore Flow achieved significantly higher bond strengths than Filtek Flow ($p = 0.03$), Tetric Ceram ($p < 0.001$), and Filtek Z250 ($p < 0.001$). The bond strength of Tetric Flow was significantly higher than that of Filtek Z250 ($p = 0.003$).

**Conclusion:** For core buildup on a fiber post, dual-cure composites appear to be preferable to light-curing composites.

**Keywords:** prefabricated FRC post, core material, composite resin, dual-cure composites, bond strength, microtensile testing.

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With the improving predictability and prognosis of endodontic therapy, the need for appropriate and reliable coronal restoration of endodontically-treated teeth is increasing.[18,23] It is also likely that the need to restore endodontically treated teeth will increase as more people retain teeth into old age.[1,25]

While research has clearly shown that posts do not reinforce endodontically treated teeth,[11,20,22,24] their role in retaining a core when much or all of the clinical crown has been destroyed is not disputed. It follows that the inherent retention and stability of the post-and-core system are crucial for a successful final restoration.[9,11,24]

To overcome some disadvantages of metal posts, such as incompatibilities between their physical properties and those of dentin,[10] Duret et al[5] introduced the alternative of fiber-reinforced composite (FRC) posts. Laboratory-based studies have shown these posts to have high tensile strength and a modulus of elasticity that is similar to dentin.[3] Because of the obvious esthetic disadvantage of the matt-black colored carbon-fiber posts, quartz or glass-fiber posts, which are white in color, were introduced.[7] Recently, translucent fiber posts were introduced to achieve optimal esthetics: these posts have the added advantage of being able to

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transmit light through the post, thus permitting light-curing of the adhesive into the root canal.[3,7,13]

The use of composite resin as a core material in combination with translucent FRC posts has enhanced the reproducibility of shade and translucency of natural teeth compared to traditional cast post-and-core systems.[27] The technique is simple and predictable, and involves a direct, chairside procedure. The nature of the bonds between the glass-fiber post and the composite resin core creates a "quasi-monoblock" restoration that, according to some authors, in effect becomes an integral part of the restored tooth and positively affects the success rate.[8]

Under fatigue loading conditions, cast post and cores were found to withstand a higher number of load cycles than direct composite resin cores and demonstrated better resistance to fracture than prefabricated fiber-reinforced post systems.[12,19,21]

A variety of composite resin materials can be used for the core buildup procedure, ranging from microhybrid to flowable to condensable composites,[14,15] which are in turn divided into light-activated, self-activated or dual-activated modes of polymerization. By definition, these materials differ in terms of strength, stiffness, elasticity, and other properties,[3,6] and by implication, such variations may influence the structural integrity as well as the durability of the completed restoration.

Among the studies performed on various aspects of fiber post systems, only one laboratory study has reported on the structural integrity of the core material and its adaptation to the post, and found specifically that flowable composites exhibited better results than hybrid composites.[15] Clinically, a study by Monticelli et al[16] showed that cores comprising flowable composites and retained by fiber posts were capable of providing reliable support to porcelain crowns over the two-year follow-up period. A recent study has also shown that the use of a silane agent improves the bond strength between prefabricated FRC posts and the composite resin core.[10] It would seem that greater clarification of the factors influencing the bond between post and core could contribute to clinical success.

The aim of this study was to evaluate the bond strengths between various resin composites used as core materials and an FRC post by means of the microtensile nontrimming technique. The null hypothesis was that there is no significant difference in the bond strength achieved at the post/core interface amongt the core materials tested.

## MATERIALS AND METHODS

The experimental method employed a simulated post-core arrangement. Standardized shapes, as well as distributions of the core material around the post, were obtained by constructing a silicone mold from a wax mock-up of the core on a post (10 mm in diameter and 10 mm in height). The design of the mold ensured that the position of the apical conical end of the posts was located in the silicon mold in a manner which consistently centralized the posts in the core "space" before buildup, and also restricted the composite placement to the cylindrical region of the posts (Fig 1).

**Table 1 Group composition and sample size**

| Group | Material | Type | Manufacturer |
|---|---|---|---|
| Group 1 | Multicore | Flowable | Flowable Ivoclar-Vivadent, Schaan, Liechtenstein |
| Group 2 | Tetric Flow | Flowable | Ivoclar-Vivadent, Schaan, Liechtenstein |
| Group 3 | Filtek Flow | Flowable | 3M-ESPE, St Paul, MN, USA |
| Group 4 | Tetric Ceram | | Hybrid Ivoclar-Vivadent, Schaan, Liechtenstein |
| Group 5 | Filtek Z250 | Hybrid | 3M-ESPE, St Paul, MN, USA |

The posts used were FRC Postec Plus, size 1, with a maximum diameter of 1.5 mm (Ivoclar-Vivadent, Schaan, Liechtenstein). Each experimental group, one for each type of resin core material (Table 1), was composed of 10 samples consisting of an FRC post and a resin core.

Post surfaces were cleaned with 37% phosphoric acid etching gel for 60 s according to the manufacturer's instructions (Total Etch, Ivoclar-Vivadent). The posts were then thoroughly rinsed with water and dried. Post surfaces were treated with a silane agent for 60 s (Monobond-S, Ivoclar-Vivadent). After silane application, surfaces were carefully dried and the core portion was built up onto the post. Each post was positioned in the mold, and the buildup was performed using the appropriate composite according to the manufacturer's instructions. Flowable composites were applied onto the post directly from the syringe in 1- to 2-mm-thick increments (Fig 1), which were carefully adapted onto the post surface and each separately cured for 20 s with a halogen curing light (Astralis 10, Ivoclar-Vivadent, intensity 1200 mW/cm$^2$). The material was always irradiated directly from the open upper side of the mold and through the post. Similarly, hybrid composites were applied in 1- to 2-mm increments and cured from the upper side of the mold. When the mold was completely filled, the built-up post-core cylinder was removed, and a further 20-s irradiation was done on the underside of the cylinder (which had faced the floor of the mold) in order to ensure complete polymerization of the core material.

Immediately after completing the buildup, the specimens were cut and tested, so as to quantify the bond strength reached by the materials at the time when clinical procedures of core preparation, impression, and temporary crown adaptation and cementation would usually be performed. After having sectioned off the projecting portions of post from below and above the core cylinder, each cylinder of material was secured in the holding device of an Isomet saw (Buehler, Lake Bluff, IL, USA). Then, by means a water-cooled diamond blade, two parallel longitudinal cuts were performed in order to expose the post surface throughout its length (Fig 2). Progression of the cutting was controlled visually by the operator. As a result, a 1-mm-thick slab was ob-

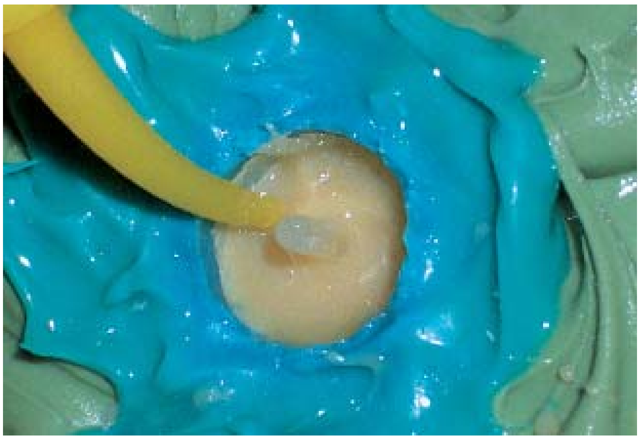

**Fig 1** Sample buildup using the silicon mold.

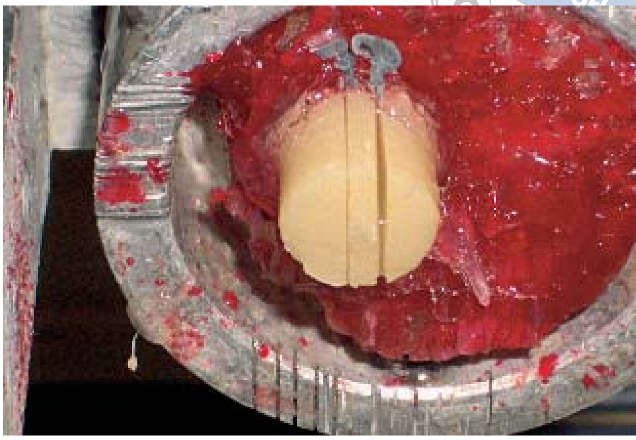

**Fig 2** First two sections on the opposing outer limits of the post.

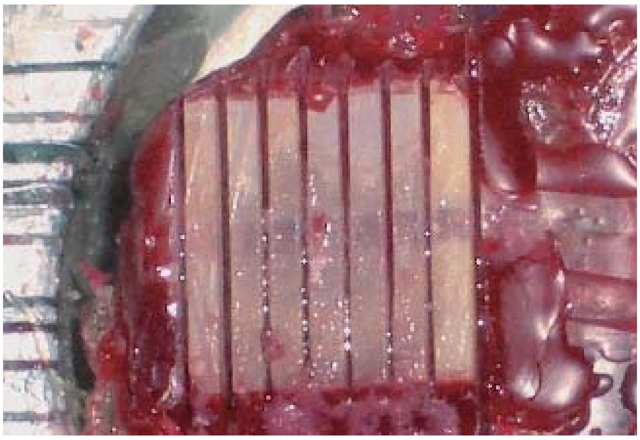

**Fig 3** Serial sections of the slab yielding several sticks for tensile testing.

**Fig 4** Mounting of a study sample on the universal testing machine.

tained from each cylinder, each comprising post material in the center and the core buildup on each side. From the slab, 1-mm-thick slices were serially sectioned transversely (Fig 3), producing 7 or 8 slices, and, in turn, 45 to 50 slices for the 10 slabs.

Each slice was glued with cyanoacrylate (Zapit, Dental Ventures of America, Corona, CA, USA) to the two free-sliding components of the jig of a universal testing machine (Controls, Milano, Italy). This setup was designed to apply purely tensile forces to the two opposite post/core interfaces (Fig 4). Specimens were loaded at a crosshead speed of 0.5 mm/min until failure occurred at either one of the stressed interfaces. Bond strength was obtained by dividing the load at failure in Newtons (N) with the bonding surface area ($mm^2$), and expressed in MPa. As the bonded interface was curved, its area was calculated using a mathematical formula previously applied by Bouillaguet et al[4] for similar purposes.

The level of significance was set at $p < 0.05$. Statistical analyses were performed using SPSS version 11.0 software (SPSS, Chicago, IL, USA). Differences among the groups were assessed by one-way ANOVA with microtensile bond strength in MPa as the dependent variable and core materials as independent variables, followed by Dunnett test for post-hoc comparisons.

**Table 2** **Mean bond values, standard deviations, and percentage of pre-test failures (nt: total specimens yielded by the cutting process, nf: specimen remaining after eliminating premature failures (PF). Means and standard deviations exclude premature failures)**

| Pre-test | | | | Significance | | | |
|---|---|---|---|---|---|---|---|
| Core material | nt | nf | PF | | Mean | SD | |
| | | | | failures (%) | | | (p < 0.05) |
| Multicore Flow | 55 | 50 | 5 | 9.09% | 17.29 | 6.02 | A |
| Tetric Flow | 45 | 31 | 14 | 31.11% | 16.37 | 6.92 | Ac |
| Filtek Flow | 48 | 31 | 17 | 35.41% | 13.19 | 5.35 | Bc |
| Tetric Ceram | 47 | 38 | 9 | 19.14% | 12.38 | 4.34 | Bc |
| Filtek Z250 | 42 | 32 | 10 | 23.81% | 10.75 | 5.43 | B |

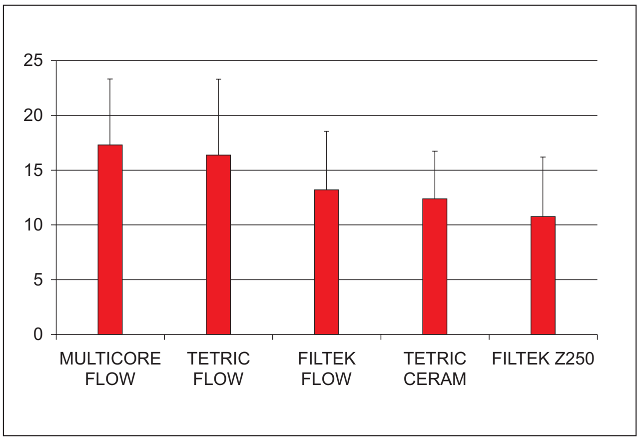


**Fig 5** Mean and variance distribution of bond strengths.

## RESULTS

To ensure a normal data distribution, premature failures were eliminated (slices that fractured at any stage prior to loading and considered as "zero bonds"). Thus, the distribution of the remaining bond strength data was normal (Kolmogorov-Smirnov test, $p = 0.18$). Bond strength values, standard deviation, and percentage of premature failures for each group are reported in Table 2. One-way ANOVA showed statistically significant differences between the groups ($p < 0.0000001$).

According to Dunnett test, MultiCore Flow achieved significantly higher bond strength than Filtek Flow ($p = 0.03$), Tetric Ceram ($p < 0.001$), and Filtek Z250 ($p < 0.001$). The bond strength of Tetric Flow was also significantly higher than that of Filtek Z250 ($p = 0.003$) (Fig 5).

## DISCUSSION

Among the different materials currently available on the market for core buildups, heavily filled light-activated hybrid resin composites could conceivably have the advantage of providing stable support to the overlying crown, whereas more elastic composites such as flowable light-activated materials would seem to have easier handling characteristics. Using SEM imaging, Monticelli et al[14] recently studied the presence of voids and/or bubbles at the post/core interface and/or within the core itself. They reported that flowable materials achieved a better integration with the fiber post by minimizing bubbles and voids within the core bulk and/or at the core/post interface. This is consistent with the findings of Akkayan and Gulmetz who showed that such voids would jeopardize the integrity of the post/core restoration, and in turn that of the overlying crown.[2]

However, microscopic investigations usually only provide a qualitative, or perhaps an implicit, evaluation of the characteristics of a material or an interface.[14] The quantitative, or more explicit, aspect was investigated by Monticelli et al,[17] who found that autopolymerizing and flowable composites provided the best bond compared to other materials, while SEM observations of debonded surfaces showed a high prevalence of adhesive fractures.[17]

The present study was designed to further assess bond strengths values with respect to different core products. It showed that bond strength values are variable; thus, the null hypothesis is rejected that there is no significant difference in the bond strength achieved at the post/core interface using FRC posts and the core materials tested.

Differences in bond strength cannot be explained solely by the findings observed in this study. It can be speculated that the composition of the products themselves could affect the results observed, since the FRC Postec Plus post, and Multicore Flow and Tetric Flow composite resins are produced by the same manufacturer and may thus be more compatible (possibly with regards to chemical composition) with each other rather than with Filtek Flow and Filtek Z250. Nevertheless, it seems reasonable to state that flowable composites behave better and yield higher bond strengths than nonflowable composites. The chemical composition and filler content may also be a factor in determining bond strength. A significant finding in this study was the occurrence of premature failures, and it can only be hypothesized that Multicore Flow showed fewer premature failures due to the fact that it is a dual-cured composite resin, whereas all the other materials tested were light-cured composites.

While the present study was confined to testing the FRC Postec Plus post, many types of prefabricated posts are currently available with a wide variety of carbon, quartz, or glass fibers, or a resin matrix. This suggests that a wider range of factors than those presently tested, such as chemical composition, physical properties, and handling, could affect the outcomes observed. Furthermore, the role of silanization, while it is considered beneficial to bond strength on the basis of previous findings,[10] may affect different material combinations differently. The absence of a control group without silanization makes this impossible to comment upon at this stage, but further research is indicated to address this question.

Within the limitations of this study, flowable composites would appear to be superior to hybrids as core buildup materials for fiber-reinforced resin posts as regards bond strength. However, further research is needed to confirm these results and better identify the factors that affect bond strength, as well as to better characterize the overall requirements for an optimal buildup material in the clinical approach described for restoring the endodontically-treated tooth.

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**Clinical relevance:** For core buildup on a fiber post, dual-cure composites appear to be preferable to light-curing composites.