Rationale for Low-Modulus Endodontic Posts

Fiber reinforced composite posts appear to have attained a permanent and integral role in the re-engineering of the endodontically treated tooth. The inherent differences in clinical behavior between metallic and fiber posts and the potential benefits to clinician and patient were not well understood or even apparent when Duret and Reynaud developed and patented the first generation of fiber posts in 1989 and 1993 (ComposiPost in 1989; C-Post in 1993). These 2 clinicians were merely looking for a post material that would not predispose root damage, which had been a serious drawback in their clinical experience with prefabricated metal posts, and cast posts and cores.

This article discusses the physical properties and clinical rationale for the use of fiber endodontic posts, and demonstrates the use of 3 devices that improve the technique for bonding fiber posts to tooth structure.

BACKGROUND

Young’s Modulus of Elasticity (relative stiffness) of fiber posts is similar to that of dentin. After nearly 2 decades of worldwide clinical service and observation, it is evident that this mechanical property alone allows the bonded fiber post/composite build-up assembly to absorb and dissipate mastication and traumatic stresses rather than redistribute the stresses to another part of the tooth.6,7 This appears to be true whether the fiber post contains carbon, glass, quartz, zirconia oxide, or a combination of these fiber types, and regardless of the overall shape (tapered or parallel) of the fiber post.3,6

Low-modulus fiber post-composite cores dramatically outperformed the traditional custom cast post in a 4-year clinical evaluation,2 and few medium- and long-term clinical studies have been published comparing prefabricated metal posts to fiber posts. However, research documents that certain fiber posts offer more than adequate flexural strength,8,10 fatigue resistance,12,13 and even improved fracture resistance13,14 in restored teeth. Other studies27-29 demonstrate more favorable fiber post resistance to microleakage when compared to metal posts. Further, bonded, tapered, microrerative (smooth to the naked eye) fiber posts can provide retention to the tooth equal to or greater than the parallel metal ParaPost.30

All types of post-core restorations can fail clinically, but clinical observations and the dental literature offer consensuses that failures involving low-modulus post-core buildups are almost always noncatastrophic and allow retreatment.21-24 In cases where the post-core does not fail, but the endodontic treatment requires reaccess, studies conclude that fiber posts can be atraumatically removed in less than 7 minutes.22,25-27 The clinical procedure, however, requires a few minutes more to remove all of the fibers and cement.30

While the first generation of fiber posts were as aesthetically unacceptable as their metal predecessors, since 2001 clinicians have had a wide choice in fiber posts, translucent or tooth-shaded, and a variety of tapered, pointed, parallel shapes. From a clinical perspective, all other mechanical properties being equal, very translucent posts offer one clinical advantage over the same post in an opaque version—polymerization energy conductivity. Manufacturers of fiber posts advocate use of dual-cure resin cement because of the clinical track record, expediency, and comparative insolubility. Published data confirm that translucent fiber posts help to conduct some light-polymerization energy into the post space.29,30 How “deep,” how “much” energy, and other factors vary according to post thickness, post composition, type of curing light, and curing light output. Regardless, using the post’s intrinsic fiber-optic bundle to stabilize the post within a few seconds expedites the restorative technique by several minutes.

Radiographic visibility is an important clinical attribute, which is achieved by different means and by various manufacturers using combinations of different fibers and radiopacifying filler particles. The clinician should be aware that these endodontic post brands offer different levels of radiopacity as defined by ISO Specification No. 4049.31

By their nature, and in contrast to stainless steel posts and base metal castings, fiber posts are incapable of corrosion or galvanic reaction, and they have been proven biocompatible to the satisfaction of the US Food and Drug Administration. All of the physical attributes of fiber posts that have been described were either known and were intended at the time of invention or have been improved gradually over the last 15 years. For decades it was assumed that metal posts would reinforce the endodontically treated tooth while securing the core and crown assembly. There is now a body of evidence suggesting that fiber posts can actually improve the prognosis of endodontically treated teeth in terms of fracture resistance32-35 and in clinical cases presenting with less remaining tooth structure.31,36 The amount of remaining tooth structure (walls continued on page 68
CEMENTATION OF FIBER POSTS
The core material of choice for use with fiber posts, regardless of brand shape, fiber opacity, or any other consideration, is dual-cure composite. The first alternative would be light-cure composite, and the least acceptable option is self-cure (chemical-cure) composite. Research cited above in references 1 to 32 addresses the mechanical behavior of fiber posts compared to metallic posts, by themselves (without surrounding tooth structure) and when placed in function in teeth. In clinical trials with some observations as long as 11 years, the most common failure mode directly related to the fiber post/core (versus periodontal or endodontic failure, noncompliance, etc.) is dem- cementation. As little as 0.37-39 1%-40-52 2%,41,42 and 3.5%-43 to as high as 4.3%-44 has been reported. While this level of detachment is no worse than their metal predecessors, efforts should be made to reduce the potential for any clinical failures.

Regarding cementation, the interfaces of critical interest to the clinician are:
1. Post surface to resin cement.
2. Resin cement to bonding adhesive.
4. Post to core composite.

Many authors44-57 have studied various means of enhancing the bond between the surface of the post and the resin cement, using primers, silane (both factory-applied and chairside), air-abrasion, etching, and other methods. Results are contradictory and improvement is minimal. The most challenging and controversial of these interfaces is bonding to the dentin in the deep (10 to 14 mm) post space. In clinical cementation and in vitro testing (pull-out, push-out, and microtensile) the interface that usually fails first, albeit at respectable loads, is the bond to the dentin. Variations in the available bonding/cement systems’ cavity configuration (C-factor) may contribute to this. The C-factor has a significant effect on the magnitude of shrinkage stresses that result from polymerization. The C-factor is defined as the ratio of the bonded surfaces to the un-bonded surfaces of the restoration. The Class I cavity has the highest C-factor of 5 (ie, 5 bonded: 1 unbonded, a Class 2 restoration is 4:2, thus a C-factor of 2). Further, since it is known that in routine cases of bonding to dentin with flat-surface geometry (such as in vitro studies) current adhesives and cements work reliably, the reason for cementation failure of fiber endodontic posts is likely related to clinical technique. Therefore, the following technique factors should be considered:
- Cement selection—resin versus glass ionomer
- Self-cure versus dual-cure versus light-cure
- Etch-bonding agent + cement versus self-etch/self-adhesive cement
- Surface treatment of interior dentin
- Interaction with different sealers and obturation materials (ZOE, noneugenol, new products).

GREAT POST, POOR BONDING
Historically, the luting of a post was merely a small “step” in the prosthetic process of rebuilding a tooth. It was
accomplished by mixing a powder-liquid luting agent, then buttering the post with the cement and inserting it into the canal. This insertion method is still being taught in many institutions. The technique prevents cement from coating the bottom one third (or more) of the canal since the cement on the post is subjected to small forces upon insertion and thins as the post is inserted, and ultimately little if any luting agent is present in the bottom of the canals (Figure 1). This is easily experienced when placing a parallel metal post, since one of 2 results typically occurs:

1. The post fully seats with minimal resistance.
2. If cement does reach the apex, the post experiences hydraulic rebound and begins to “lift” up out of the canal due to trapped cement and/or air that could not be vented.

(Note: During certain procedures, some clinicians may use a Lentulo spiral device to deliver cement alone into the root canal, but this device cannot be used to deliver etchant to the bottom of the canal as required for proper bonding of the post as discussed in this article.)

Today it is well understood that adhesively bonded resin cement is the standard protocol for placing a fiber post. How the post is bonded is as important as which post is selected.57 59 Bonding an endodontic post is a “blind” procedure, and certain devices and techniques (discussed below) may be helpful in achieving optimal results.

In a recent discussion with Dr. Phillip Brown,60 he told me how he devised a simple experiment for dentists attending a recent continuing edu-

Figure 5. Canals after rinsing with standard air/water syringe. Note residual etchant still in the canal.

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No one successfully dispensed etchant down the entire canal, including those who also used paper points (Figure 4).

It is easily observed that upon injecting etchant into the canal with a standard tip, the etchant tends to block the canal about halfway down, which creates an air bubble in the apical portion of the canal. Paper points or instruments cannot transport etchant farther down the canal since the entrapped air cannot be vented coronally. The air acts like a balloon and prevents migration of any etchant to the apical region.

In part 2 of the test, the participants rinsed out the etchant that they had placed with the PVS cover in place. Considering the results of the first part of the test, the participants became determined to fully rinse away the etchant. Several participants spent almost one full minute attempting to rinse the canal, which was far more time than they would likely use at chairside. Using the standard air-water syringe (no one requested any other device), all participants failed to completely remove the etchant (Figure 5). Turbulence in the coronal one third of the canal prevented water from reaching the bottom and fully removing the etchant.

Research and clinical experience have shown that restored teeth fail predominantly by debonding of the post. However, the weakest link and typical failure location is at the cement-dentin interface, not at the post-cement interface. Bonding within the root canal presents a clinical challenge due to poor bonding in the apical portion of the canal. The higher bond strengths are at the coronal end. Potesta, et al examined 3 resin cement systems to test the effect of different etching techniques on bond strength. UniCore fiber posts (Ultradent Products) were used with all 3 cements. The cements tested were: (1) PermaFlo DC (Ultradent Products) resin cement utilizing an etch-and-rinse adhesive; the etch and rinse technique utilized a TriAway irrigation device (Ultradent Products) for the air/water syringe and a LucVac vacuum adaptor (Ultradent Products) for the high-volume suction; (2) Panavia F 2.0 (Kuraray) with self-etching ED Primers; and (3) UniCem (JM
ESPE) as a self-adhesive cement. The results are shown in Figure 6. Note that for the controls (Panavia F 2.0 and RelyX UniCem) the bottom three fourths of the canal show dramatic drops in bond strength. As seen with the PermaFlo DC/TriAway group, using the TriAway and Leur Vacuum adaptor produced relatively consistent bond strengths through the entire length of the canal. Further, the absolute best bond values for the controls were still less than the lowest bond value for the PermaFlo DC group.

**Figure 7.** A standard etchant tip is shown on the bottom; an Endo-Ex extended length tip is shown above.

**Figure 8.** Air/water syringe equipped with the TriAway Adapter with Leur lock tip (Ultradent Products).

**Figure 9.** Leur Vacuum Adapter with Leur lock tip (Ultradent Products).

**Figure 10.** Exposure of the gutta-percha.

**THREE DEVICES FOR MAXIMIZING ENDODONTIC POST BONDING TECHNIQUE**

There are 3 devices that can easily be incorporated into the bonded post technique that will ensure uniform and predictable bonding of the post:

1. Long cannula Leur Lock delivery tips for the etchants that reach the bottom of the canal. These are typically about 18 to 20 mm long versus a standard etchant tip which is about 10

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**Figure 11.** UniCore post and drill (Ultradent Products).

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**Note:** Although the EndoActivator produced very little extrusion, it may not be used to remove any pre-natal reagent solution in the root canal. This, in safety, is a prerequisite to allow the Supernatant to effectively deliver the irrigant.
to 12 mm in length. These disposable tips, shown in Figure 7, are offered by many companies in several gauges. A 22-gauge tip will fully navigate almost any size post hole.

2. TriAway air/water adaptor, equipped with a long cannula tip.

This device slides over the air-water syringe and supplies an endless amount of water for rinsing. It can also deliver a stream of air down the canal for drying adhesive solvents. The TriAway (Figure 8) can be disinfected and reused. A Stropko Irrigator (SybronEndo) is another device used in the same manner. The Stropko is metal and autoclavable.

3. The Leur Vacuum Adapter (Figure 9) fits into any standard chairside vacuum valve. It is composed of 2 pieces: a standard high-volume suction barrel and a clear insert with threading to accommodate any Leur Lock tip. This device will suction fluid out of the canal and pull high volumes of air across the canal thus evaporating solvents from adhesives, and can be used to lightly vacuum excess moisture out of the canal while leaving it moist for proper bonding. This device eliminates the laborious and tedious use of paper points and is fully autoclavable.

The following clinical case describes how these simple devices can be used to ensure that the canal is properly treated for bonding a fiber endodontic post.

**CLINICAL TECHNIQUE**

A 38-year-old male was referred after completion of endodontic therapy on the maxillary left lateral incisor. The facial enamel was chipped and approximately one third of the distal clinical crown was missing. A post-and-core buildup was initiated with the intent of a full coverage crown in the future.
The temporary restoration was removed and the tooth opened and prepared for the buildup; the gutta-percha was exposed for post placement (Figure 10). Based on the size of the obturated canal, a No. 1 UniCore Fiber Post (Ultradent Products) was chosen (Figure 11). UniCore Fiber Posts possess higher flexural and tensile strength than metal posts while having a modulus similar to dentin, virtually eliminating the risk of root fractures. \(^{15}\) The post has a tapered root end with a parallel coronal end for maximum surface area for core bonding. The UniCore drills (Figure 11) are unique in that they are not end-cutting drills. Rather, the heat-generating tip plasticizes the gutta-percha, then the side flutes discharge the debris coronally. With this system, no other drills are required.

With proper isolation, the canal and the super structure can all be etched in one application. The etchant is delivered to the bottom of the post canal first....

Following rinsing of the etchant, the Leur Vac Adaptor, equipped with a 22-gauge long delivery tip, was used to lightly vacuum the canal, leaving a moist surface for application of the bonding agent (Figure 12). Rubber dam isolation allows application of the adhesive to both the canal and preparation super structure simultaneously and without concern for contamination. The adhesive was applied (Figure 13) using a Navi FX Tip.
Figure 20. Final aesthetic buildup around the post.

(Ultradent Products) on the adhesive syringe. This particular tip allows predictable placement of the adhesive to the apical extent of the canal while the bristles help scrub the adhesive into the sidewalls, much like a tight tube cleaner. Air drying and light curing were then accomplished.

PermaFlo DC resin cement, with a new intraoral “goose neck tip” (Figure 14) was injected directly into the canal from the apical extent (incisally) to eliminate air bubbles. The canal was now completely filled with cement to prevent “joint starvation,” eg, bubbles and voids, between the post and dentin. The tapered UniCore Post, with its specially engineered tip, will vent excess cement coronally upon insertion.

The No. 1 UniCore Post was inserted into the cement-filled canal and the excess was spread over the base of the post (Figures 15 to 20). Since the UniCore Post conducts light, a curing light was then directed down through the post for 40 seconds to polymerize the cement. The clinician can now proceed directly with the buildup without any loss of chair time.

Since a crown was not immediately placed, an aesthetic composite was selected for the final restoration. Incremental layers of multiplicity nanohybrid were placed and cured. Note that the post was cut off during adjustment of the lingual surface and remains as part of the restoration. Unlike metal posts that require one to 2 mm of core material coverage, the UniCore Post can be trimmed to be a part of the buildup since it bonds directly to the composite and has a modulus similar to that of the remaining tooth and buildup.

The post and buildup restoration can be compared to the original clinical presentation by viewing the preoperative and postoperative radiographs (Figure 21a and 21b). The fiber post is best visualized on the postoperative film by first finding the coronal termination point of the gutta-percha, then looking for the radiopaque post above it. Note in this case how well defined the post outline is compared to the preoperative film. The post can be more difficult to see when looking in the coronal one third of the canal. Since the UniCore post has about the same radiopacity as composite, it may be more difficult to see where the cement and composite become thicker. Determining the presence of a good fiber post is no different than visualizing a composite versus an amalgam—once you know what to look for, it is relatively easy. Also note that the post has a “clean” fit against the gutta-percha: that is, the post hole diameter has not been over-prepared such that the post is wider than the gutta-percha.

CONCLUSION

Young’s Modulus of Elasticity of fiber posts is similar to that of dentin. This mechanical property alone allows the bonded fiber post/composite buildup assembly to absorb and dissipate mastication and traumatic stresses rather than redistribute the stresses to another part of the tooth. This characteristic appears to be true whether the fiber post contains carbon, glass, quartz, zirconia, oxia, or a combination of these fiber types, and regardless of the overall shape (tapered or parallel) of the fiber post.

Low-modulus fiber post/composite cores have been shown to outperform the traditional custom cast post. While few medium- and long-term clinical studies have been published comparing prefabricated metal posts to fiber posts, there exists a plethora of in vitro research documenting that certain fiber posts offer more adequate flexural strength, fatigue resistance, and even improved fracture resistance in restored teeth. Other studies demonstrate more favorable resistance to microleakage compared to metal; bonded, tapered, microreten- tive fiber posts can provide retention to the tooth equal to or greater than the parallel metal MetaPost.

Adhesively bonded resin cement is the standard protocol for placing a fiber post. How the post is bonded is as important as which post is selected. Even the most meticulous technique for syringing impression material into a sulcus can periodically lead to the need to repeat the procedure. Bonding an endodontic post is a “blind” procedure, similar to endodon- tity therapy itself, and therefore must incorporate similar endodontic devices and techniques to achieve the best results. A clinical technique for achieving successful bonding of fiber endodontic posts has been presented.

References

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