Fiber Post Techniques for Anatomical Root Variations

The purpose of this article is to identify and describe the newer materials and techniques deemed as viable alternatives to metallic post/cores, and to propose a rationale for the selection of one product or restorative technique protocol over others for simple and complex post-endodontic restorations. These are indicated where remaining coronal tooth structure is less than 50% and/or the core strength is compromised by the endodontic access opening.

BACKGROUND

Custom cast posts were first described more than 100 years ago, and utilized the optimal impression techniques, casting, and cementation materials available at that time. In most of the world, cast posts (still taught in some dental schools) have been supplanted in clinical practice by prefabricated posts made either of metallic alloys or from fiber-reinforced composite. In even a cursory review of the literature, the evidence-based support for a trend away from metal posts to fiber posts is abundant and conclusive:

- Fiber posts, regardless of brand, are anisotropic and have a modulus of elasticity similar to that of dentin (~20 GPa), which allows the post to flex slightly (microscopically) with the tooth and dissipate stress, thereby reducing the likelihood of damage to the root.1-4

- Fiber posts are not susceptible to galvanic or corrosion activity; the latter of which is responsible for a high percentage of failures with cast posts5 which, in turn, fail twice as often (clinically) as do prefabricated metal posts.6

- Fiber posts are available in translucent and tooth-colored versions (the original black carbon posts are passé), which are aesthetically invisible under all ceramic crowns, veneers and resin restorations, and also mitigate the effects of the dark root syndrome (Figure 1).7,8

- Fiber posts (excepting a South American post design that has a metal wire running through its long axis) are more easily and safely removed “by hollowing them out from the inside,” should re-treatment ever become necessary.9-12 In fact, cemented metal posts may further limit or complicate endodontic treatment options if these become necessary.13

While all brands of fiber posts appear to have these commonalities, they are not all the same....

While all brands of fiber posts appear to have these commonalities, they are not all the same; they can vary considerably from brand to brand in terms of composition and microstructure. The difference in the manufacturing process of the posts can significantly influence their mechanical properties,14,15 and thus their clinical performance. Furthermore, a connection can be found between the data obtained with SEM observations of fiber posts and their clinical behavior. SEM photographs (Figures 2 to 4), taken at the same (700x) magnification, show the variations in size of fiber, orientation, number of fibers, amount of composite, and the relative percentages which varies from fiber post to fiber post. In fact, posts that have more imperfections in the matrix will have a less compact and even structure, and thus are weaker and less resistant to load stress.14

Increases in the mechanical properties (fracture strength) appear directly proportional to the density of fibers and to their interface/bond to the matrix.16 In addition to influencing flexural strength, the fiber type, density, and uniformity of microstructure also affect the radiopacity and fatigue resistance. Figure 5 shows the relative radiopacity of various fiber posts side by side, and Figures 6 to 8 demonstrate the same variation in an extracted tooth that is prepared for a 1.5 mm tapered fiber post. It is obvious that the Macro-Lock Illusion X-RO (CLINICIAN’S CHOICE) is the most radiopaque in this sampling of fiber posts (Figure 7).

Quartz fibers are among the most radiopaque fibers being used,17,18 and the quartz fiber posts have proven superior in fatigue resistance to glass fiber posts15 and to metal posts.19 Fatigue tests can be considered as the most relevant methodological standard for evaluating and predicting the behavior in an oral environment.18 The in vitro studies that more than any other permit the fair prediction of yielding and, therefore, the

continued on page 106
Fiber Post Techniques... continued from page 104

long-term behavior of the restoration, are the fatigue tests.20,21

Into the 1970s, it was hoped that metal posts could help reinforce weakened endodontically-treated teeth. In the 1980s, Sorensen, et al22 surmised otherwise. Today there is a growing body of in vitro evidence that if properly placed, low modulus restorations (quartz fiber posts with bonded composite cores) with varying amounts of remaining tooth structure can, in fact, provide some restrengthening of weakened teeth restored with MOD restorations, veneers, or full-crown techniques.22-26 Figure 9 shows a high-power SEM of the adaptation possible with an appropriately sized bonded fiber post creating a “monoblock.” A ferrule of 2 mm has to be provided for the reconstruction of endodontically treated teeth by post and core techniques. (Studies show that increasing the length of a ferrule from 1 to 1.5 mm in a quartz fiber post does not significantly increase fracture loads, but an increase to 2 mm results in higher fracture thresholds.)

Now the clinical observation of carbon27-30 or glass and quartz fiber31-34 post restorations offer admirable performances at 7 to 11 years’ conclusion,35 and the difference in failure rates—particularly catastrophic failure rates—between fiber posts and cast posts is no less compelling at 4 years’ service.36

The placement of a single fiber post in a relatively “round” and minimally tapered conservative root canal has been described in many articles and is now appearing in textbooks. There is evidence that (unlike metal predecessors) there is no difference in the performance between tapered and parallel fiber posts.37-38 However, it is self-evident to an experienced clinician that parallel posts may often require the removal of additional dentin and the creation of acute internal angles (“stress masts”). Therefore, the tapered apical parallel body shape is preferable39-41 if only for the sake of dental conservation. Figures 10 and 11 show the same tooth as above, prepared for a tapered 1.5 mm fiber post. It is obvious from the radiograph that more tooth structure at the apical end of the canal would need to be sacrificed to allow the parallel 1.5 mm posts to seat to the same length, needlessly weakening the remaining root structure.

So, then, what is the contemporary technology protocol, when faced with a flared, ovoid, or figure-8 canal?

Circular parallel post systems are only effective in the most apical portion of the post space, because the majority of prepared post spaces demonstrate considerable flare in the coronal half. Similarly, when the root canal is elliptical, a parallel-sided post will not be effective unless the canal is considerably enlarged,42 thereby needlessly removing extra dentin. From a clinical perspective, when assessing posts that have failed, many are in fact cemented or bonded to areas in the canal still occupied by gutta-percha. One of the causes for the lack of resultant retention is due to this oversight, which is a direct result of preparing a round canal space with a rotary instrument in a canal which is never round. There are 2 prefabricated posts available (in limited market areas) that are designed with a rounded, tapered apical extremity, and an oval coronal section (PeerlessPost [SybronEndo] and ELLIPSON [RTD]).

The low modulus approach needs to be adaptable to the over-flared canal, while addressing the inherent challenges, which include C-factor stress and S-factor stress,43 polymerization shrinkage and, presumably, microleakage.

Most fiber posts on the market come in cylindrical sizes that mimic their metallic ancestors, so that the practitioner may use the drills already purchased. However, as previously discussed, a tapered preparation is the most noninvasive. Unlike fiber posts, as the diameter of metal posts increases, so does the stress transfer to the tooth, and, logically, does the likelihood of post splits.

There are some tapered quartz fiber posts that come in extra large sizes that range from 0.8 mm at the apical tip to 2.3 mm at the coronal extreme (DT Light-Post [RTD, BISCO]) and Macro-Lock Post [RTD]). These sizes exceed the diameters available in most brands, and are capable of fitting most root canal treatments without further instrumentation.

The authors will now describe and suggest an approach and technique for the inevitable variations presented by prepared and filled root canals which fall into 3 proposed treatment categories.

THE SIMPLE CANAL

In a “simple” case, where the canal treatment results in the typical tapered conservative shape (less than 25% larger than the fiber post [Figure 12]), a single fiber post can be inserted and covered with a composite core build up in preparation for the prosthetic restoration. The clinical protocol for this type of case is as follows:

All procedures inside the root canal should focus on the bottom-up approach; the canal is prepared with the matching sized post drills and posts, and all remnants of gutta-percha must be removed from the walls of the post space to facilitate bonding. The fiber post is generally shortened to the height of the core with a diamond bur before the bonding procedure is started, but it can also be cut with a diamond bur after the core is cured. If using a self-curing resin cement, the post should always be cut to length first, so as not to vibrate the post while the cement may be setting. Fiber posts can be cut to length after the core is placed, but color changing posts are unique. A color changing post should be cut 1.5 mm short of the anticipated coronal extent of the core, and thus be buried in the core composite. This is done to prevent reappearance of the color under translucent ceramics due to exposure to.
intraoral temperature changes when the patient ingests cold beverages or food. The clinical presentation and treatment of a case that is typical for the simple canal is shown in Figures 13a to 13n. The tooth is isolated and gutta-percha is removed with a small starter drill (Figure 13b), and the post space is created with the appropriate size taper drill (Figure 13c). Care should be taken to match the post, as close as possible, to the size of the existing canal space rather than over preparing the canal for a large post. At this time, all remnants of gutta-percha should be removed and verified visually with magnification. (Some practitioners use chloroform to dissolve any remaining gutta-percha in the post space area.) The fiber post (Macro-Lock Illusion X-RO is tried in the canal (Figure 13d). Then, it is trimmed to length with a diamond bur to prevent chatter and possible damage to the post. To decontaminate the post after try-in and length adjustment, it is cleaned with alcohol prior to bonding. The canal is acid etched by placing the acid gel from the bottom up using a 20- or 22-gauge needle tip (Figure 13e). This is done to keep an air lock from forming below the etchant, which would prevent etching of the entire canal space. It has been shown that agitating the acid with a microbrush during this 15-second procedure increases bond strength. The canal is rinsed with water, again from the bottom up, using a 20- or 22-gauge needle adapted to either a Stropko Irrigator (CLINICIAN’S CHOICE) or TriAway Adaptor (Ultradent Products), to thoroughly wash and remove the acid gel out of the canal space.

All procedures inside the root canal should focus on the bottom-up approach....
This cannot be achieved with a typical 3-way syringe, which can leave some acid in the canal, interfering with the chemical setting reaction of a dual- or self-cure cement. The canal is lightly dried using air from the bottom up and then double checked with a paper point. The adhesive bonding agent is placed with a microbrush and agitated into the opened tubules of the root canal (Figure 13f). Air is delivered from the bottom up and excess bonding agent and pooling is prevented by inserting a paper point to absorb any excess. The bonding agent is then light-cured with a high-power, broad-spectrum LED curing light for at least 30 seconds (Figure 13g). It must be remembered that light intensity for some curing lights varies drastically with distance, so the cure must be adequate. There are only three possible solutions for this: (1) a dual (photo and chemical) activation adhesive, (2) conducting the light through the post and photoactivating the bonding agent with a paper point, and (3) bonding agent is cured with a high output curing light for 20 seconds.

After water rinsing from the bottom of the canal up, and light drying, the canal is checked for excess moisture with a paper point; the bonding agent is placed in the canal and lightly agitated to increase the bond strength to the dentin. This cannot be achieved if light-cured adhesives are used, undercuring will lead to failure.

The clinical preparation (Figure 13h) and light-cured (Figure 13i). Then, after the dual cure resin cement is placed into the canal with a microbrush. The post is inserted and the dual cure resin cement is light-cured for 30 seconds (Figure 13k). It is best to inject the dual cure resin cement from the bottom up rather than using the lentulo spiral. This prevents any possible air entrapment and prevents the acceleration of set caused by the lentulo-spiral drill. The core material is injected around the post, and then light-cured (Figure 13l). The final preparation of the core for the patient is shown in Figure 13m and the final Zirconia (ZirconZahn) (ceramic) restorations are shown in Figure 13n.

There are many recommendations being made for the selection of cementation media and placement technique. Standard bonding tests would support the use of a fourth-or fifth-generation adhesive system (ie, All-Bond 2 [BISCO] or One-Step [BISCO], SealBond Ultima [RTD], MPa [CLINICIAN’S CHOICE] respectively) in conjunction with dual cure or chemical cure resin cement, as being superior to self-adhesive or self-adhesive cement formulas. Clinical success with these also assumes proven chemical compatibility between the adhesive and the resin cement, and meticulous isolation, good access, vision, and technique. This is easy in the in vitro laboratory, but not always so easy in vivo.

In cases where access and/or visibility and/or good moisture control are compromised, some post manufacturers and clinicians/researchers report good results using self-adhesive, selfetching cements and resin-reinforced glass ionomer cements, particularly when using macroretenive quartz fiber posts (Macro-Lock Illusion X-RO). However, it should also be noted that some of the comparative in vitro bond strength studies (to dentin) show these newer generations of cements to be inferior to the “total-etch/moist-bonding” dual cure cementation technique. Furthermore, a post inserted like this should also have high flexural strength (minimum 1,500 MPa) since it won’t have the mechanical reinforcement that the adhesive cementation provides.

There are many recommendations for the selection of cementation media and placement technique. Standard bonding tests would support the use of a fourth-or fifth-generation adhesive system (ie, All-Bond 2 [BISCO] or One-Step [BISCO], SealBond Ultima [RTD], MPa [CLINICIAN’S CHOICE] respectively) in conjunction with dual cure or chemical cure resin cement, as being superior to self-adhesive or self-adhesive cement formulas. Clinical success with these also assumes proven chemical compatibility between the adhesive and the resin cement, and meticulous isolation, good access, vision, and technique. This is easy in the in vitro laboratory, but not always so easy in vivo.

In cases where access and/or visibility and/or good moisture control are compromised, some post manufacturers and clinicians/researchers report good results using self-adhesive, selfetching cements and resin-reinforced glass ionomer cements, particularly when using macroretenive quartz fiber posts (Macro-Lock Illusion X-RO). However, it should also be noted that some of the comparative in vitro bond strength studies (to dentin) show these newer generations of cements to be inferior to the “total-etch/moist-bonding” dual cure cementation technique. Furthermore, a post inserted like this should also have high flexural strength (minimum 1,500 MPa) since it won’t have the mechanical reinforcement that the adhesive cementation provides.

Because larger, tapered, and even double-tapered fiber posts are now offered, and these are mechanically...
compatible with the remaining tooth structure, good close adaptation of the post to the post space can routinely be achieved, with a minimum of cement thickness,\textsuperscript{40,41} thus minimizing the S-factor. It is the more flared spaces that are addressed now.

THE ANATOMICAL POST AND CORE

Polymerization shrinkage, and the stresses associated with that (the C-factor and S-factor), are a big consideration in all bonding/restorative procedures, and nowhere is the C-factor higher than it is in post cementation,\textsuperscript{43} because of the high number of involved surfaces and unbounded surfaces. Even though composite resin core materials generally have more filler and, therefore, higher strength than resin cements, the polymerization shrinkage stress is higher with 70% filler than that with 10% filler.\textsuperscript{50} This may seem counterintuitive to most dentists, but the objective is to utilize a technique that compensates for the inherent deficiencies of some materials and, in fact, actually capitalizes on them without becoming clinically cumbersome, time consuming, or with the integration of outside laboratory fees.

In an earnest attempt to address these factors, Grande, et al\textsuperscript{31} and Plotino, et al\textsuperscript{22} have described chairside techniques for adapting prefabricated fiber posts to ribbon-like, oval, or ovoid canal spaces by remodeling in essence, by whittling the post with a diamond bur to match an analog achieved through a separate procedure. The results suggest that the volume of cement is minimized, and the retentive surfaces of the post are not compromised. However, no information is offered regarding the effects that whittling a round (tapered or parallel) post brings to the other mechanical properties of the fiber post, such as structural integrity.

In the mildly flared space (Figure 14), we can create a composite "core build-down" followed by the core build-up. In the flared canal with a coronal circumference 25% to 50% greater than that of the largest fiber post (by itself) available, the authors suggest the following protocol.

In this clinical case, the canal has a moderate flare with the above criteria. The tooth is isolated, and the canal is prepared as previously with a size appropriate drill (Figure 15a). After the canal is thoroughly cleaned, the fiber post is inserted and the fit verified (Figure 15b). A water soluble separating medium is applied to the post space (Figure 15c), a light-curable hybrid composite core material (such as Grandio [VOCO]) is adapted to the prefabricated post (Figure 15d), which is then inserted into the root canal space (Figure 15e). The composite is light-cured through the light-conductive fiber post, and the post is removed from the canal (Figures 15f and 15g). When performing this technique, the clinician must look for undercuts before creating the "core build-down." It won't be possible to remove the post if cemented in those undercuts, and the procedure will have to be repeated, possibly injuring the post. After verifying the position (Figure 15h) by
marking the labial with a pencil for orientation, the canal is thoroughly rinsed and the build-down is rinsed to remove the water soluble separating medium. As in the first clinical protocol, the canal is etched with a microbrush which is agitated in the canal (Figure 15i), rinsed from the bottom up, dried from the bottom up, and any excess water removed with a paper point. The light-cured bonding agent is applied and fully cured as in the previous protocol. The dual cure resin cement is placed in the canal, the core build-down is inserted (Figures 15j and 15k), and thoroughly light-cured. After cementation, the dentin is refreshed with a diamond, the surface etched (Figure 15l), rinsed and bonded (Figure 15m); then, the core material is adapted and light-cured. The resultant free-handed core is shown in Figure 15n, which is modified with a tapered round ended diamond (Figure 15o), and the final ceramic crown (IPS e.max [Ivoclar Vivadent]) over the custom-fabricated fiber post and core is shown in Figure 15p.

This way, any shrinkage in the “build-down” is now in free space, not between the tooth and the restoration, neutralizing the S-factor effect. And it assures that the cement thickness will be minimal and uniform.38 In most cases, the air-inhibited layer on the build-down can remain intact. If in doubt, the excess cement and remaining tooth structure can be refreshed before the bonding agent and core build-up composite is applied.

It is a direct-indirect technique, and it has shown optimistic results.33-35

THE POST WITH ACCESSORY POSTS

Now, in the case where the coronal circumference has a wide flare of more than 50% greater than that of the largest fiber post available, or the practitioner is working with a ribbon, ovular, or triangular canal, the suggested technique is as follows:

As can be seen from Figure 16a, the existing canal space is now in free space, not between the tooth and the restoration, neutralizing the S-factor effect. And it assures that the cement thickness will be minimal and uniform.38 In most cases, the air-inhibited layer on the build-down can remain intact. If in doubt, the excess cement and remaining tooth structure can be refreshed before the bonding agent and core build-up composite is applied.

Published studies demonstrate the other benefits of this Accessory Post technique:

- Minimizes shrinkage in flared canals and, therefore, gap formation.
- Reduces the need for drilling in order to adapt posts to root cavity (minimizes dentin removal)
- Reduces the thickness of cement and increased fracture resistance.

Fiber posts, associated with composite resin or with accessory fiber posts, seem to be more indicated as an alternative to cast post and core in weakened roots, because of the lower risk of catastrophic failures and better stress distribution.62

It is possible to conclude that use of the fiber post, associated with accessory posts, is the method of choice for reinforcing structurally weakened roots, and provides an improvement in the load carrying ability of the restored root is validated, as opposed to the use of one single inadequately fitting post.53,64

In contemporary dental practice, there is no remaining reason to use metallic posts, custom or prefabricated.

SUMMARY

In contemporary dental practice, there is no remaining reason to use metallic posts, custom or prefabricated. Many cases that several years ago would have required a retentive post will not require that post today,
because of the many improvements in bonding agents and composite resin restoratives. However, in cases where less than 50% of coronal tooth structure remains—or in other cases wherein the judgment of the clinician a post is indicated—there are now aesthetic, non-corrosive, fracture resistant and radiopaque alternatives for all varieties that save time and money without compromise. Their most compelling advantage, regardless of the geometry or amount of residual tooth structure, is the protection from root fracture that a low modulus restoration provides.

In selecting the materials (posts, resin) for these techniques, the dentist is advised not to cut corners, and to seek the strongest and most radiopaque products available.

References