Anatomical Post Design Meets Quartz Fiber Technology: Rationale and Case Report

Abstract: Endodontically treated teeth frequently require a post and core to serve as a foundation for the coronal restoration. Remaining tooth structure, physical properties of the post material, post shape, and cement type all contribute to the success of the restoration. Post adaptation to the canal walls also represents an important element in the biomechanical performance of the prosthetic restoration. A double taper post system made of quartz fiber and epoxy was developed to conform more precisely to the shape of endodontically treated canals. Immediate benefits of this post system include minimal tooth structure removal during canal reshaping, greater post-to-canal adaptation in the apical and coronal half of the canal, and good post retention. The use of a quartz fiber/epoxy material with a lower modulus of elasticity also reduces the incidence of root fracture. Furthermore, the esthetic nature of the colors offered with this post system (translucent and off-white) provide a favorable foundation for eliminating discoloration caused by a metallic post placed under all-ceramic crown systems.

Post-and-core systems, which are used to support the coronal reconstruction of an endodontically treated tooth, are an integral part of restorative dentistry. Many post-and-core failures have been related to clinical and restorative factors, including post shape, size, composition, the type of cement, and the amount of residual tooth structure.

Once presumed to be reinforcement for the tooth, research now indicates that many posts participate directly in the transfer of stress to the root and may predispose it to fracture. The amount of remaining tooth structure and its ability to support and interact with the entire restoration are generally predictive of the clinical success of the restoration. A ferrule > 2 mm enhances resistance to fracture and restorative prognosis. Increased post length and ferrule also improve resistance to dynamic loading.

Today's clinician enjoys a much wider selection of post-and-core materials and techniques, including cast alloys, prefabricated post alloys, fiber/epoxy and zirconia posts, composite, ceramic, and ionomer-based core build-up materials. Because all of these posts possess the ability to anchor the core build-up to the tooth, posts should be compared in relation to their potential for damaging the fragile remaining tooth structure. Although still accepted as the standard of comparison, cast posts are linked to irreversible failures.

Recent comparative studies have demonstrated that the more rigid metallic posts (i.e., cast and prefabricated) tend to transfer more stress to the root than carbon fiber/epoxy posts, which increases the likelihood of vertical fracture. Sidoli and colleagues compared carbon fiber/epoxy, stainless steel, and cast posts. They reported lower failure levels with carbon fiber/epoxy posts. The lower failure rate was attributed to the post behavior and/or its bond with the composite core and luting cement. Comparison testing of different prefabricated posts revealed that carbon fiber/epoxy posts have superior fatigue strength.

Learning Objectives:
After reading this article, the reader should be able to:

- identify the components of an ideal post system.
- discuss carbon fiber/epoxy posts compared with metallic posts.
- describe ideal post design as well as esthetic requirements for post systems.
over titanium and various alloy posts.\textsuperscript{12-14} Furthermore, clinical trials have reported encouraging long-term clinical success.\textsuperscript{15}

The technology of the carbon fiber/epoxy post has been expanded so that it can be manufactured using more esthetic quartz fibers while maintaining comparable mechanical properties. This article proposes the advantages of the DT (Double-Taper) Post design\textsuperscript{6} (available from Bisco Dental Products in May 2001), based on shape, dimensions, esthetics, and placement techniques.

**Post and Root Anatomy**

Considering the compromised state of the endodontically treated tooth, an ideal post system should:
- complement minimal, conservative canal preparation.
- reduce or eliminate stresses transferred to the tooth.
- approximate the taper of the canal walls.
- be resistant to dislodgement during function.
- be retentive and possibly micromechanically attached to the tooth.

**Parallel-Sided Posts**

Research on metallic posts\textsuperscript{16,17} has revealed that parallel, passive (cemented) posts demonstrate better retention and less stress transfer when compared with active (threaded) posts. Because parallel posts do not conform well to the typical conical shape of the prepared canal,\textsuperscript{18} they generally encourage (if not necessitate) overpreparation of the apical third. At the same time, an excessive void is left coronally in the canal to be filled with cement.

\footnote{RTD, St. Egrève, France; distributed in the United States by Bisco Dental Products, Schaumburg, IL 60193; (800) 247-3368}

Ideally, canals prepared using tapered instruments would be better served by a post that approximates the same taper.

**Slightly Tapered Posts**

The development of the shape of the Endocomposipost UM\textsuperscript{TM} (carbon fiber/epoxy) was driven by the ISO gauge files and reamers used for the endodontic therapy, and by the relatively uniform (2\textdegree) taper found at the apical third of most canals. This small taper was less likely to decrease post retention and also kept a natural continuity to the endodontic treatment.

A periapical radiograph examination of many teeth treated with the Endocomposipost UM\textsuperscript{TM} revealed a less desirable adaptation in the coronal portion of the canal. An in vitro study\textsuperscript{19} using the Endocomposipost UM\textsuperscript{TM} in endodontically treated extracted teeth revealed that the apical 4 mm to 6 mm generally demonstrate good post adaptation, and the coronal half of the canal was often 2 to 3 times as wide as the apical portion and did not permit such intimate contact between the post and the canal walls. It was concluded that the nearly parallel Endocomposipost UM\textsuperscript{TM} (taper 0.02) sizes were too narrow for use with certain categories of teeth and with teeth with larger and conical canals. Based on these anatomical measurements, a new post design, the Double-Taper (DT) Post system emerged.

**Double-Taper Post**

To help determine just what an ideal shape would be, root canal treatments were performed on 967 extracted teeth (11 categories) using several rotary instruments and different techniques, including step-back and crown-down.\textsuperscript{20} Using a digital radiography system, mesiodistal
Table 1—Recommended DT Post Sizes

<table>
<thead>
<tr>
<th></th>
<th>Maxillary Teeth</th>
<th>Mandibular Teeth</th>
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<tbody>
<tr>
<td>Central Incisor</td>
<td>No. 3</td>
<td>No. 1</td>
</tr>
<tr>
<td>Lateral Incisor</td>
<td>No. 2</td>
<td>No. 1</td>
</tr>
<tr>
<td>Canine</td>
<td>Nos. 2 or 3</td>
<td>Nos. 2 or 3</td>
</tr>
<tr>
<td>First Premolar</td>
<td>No. 1</td>
<td>Nos. 1 or 2</td>
</tr>
<tr>
<td>Second Premolar</td>
<td>Nos. 1 or 2</td>
<td>Nos. 1 or 2</td>
</tr>
<tr>
<td>Molars</td>
<td>Palatal: Nos. 2 or 3</td>
<td>Distal: Nos. 2 or 3</td>
</tr>
<tr>
<td></td>
<td>Mesial No. 1</td>
<td>Mesiolingual No. 1</td>
</tr>
<tr>
<td></td>
<td>Distal: No. 1</td>
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and buccolingual width measurements were recorded at 5 mm and 10 mm from the apex, and at the cementoenamel junction (or bifurcation in multirooted teeth) (Figure 1). Means, ranges, and standard deviations were also calculated to determine an optimal size/taper for each portion of each root. Radiological observations of these extracted teeth showed a double taper (a narrower taper at the apical third and an increase in taper coronally).

Following these measurements, 22 DT Post prototypes were made and evaluated in 367 extracted teeth divided into two groups. Group 1 was sectioned sagittally; Group 2 was sectioned transversely. All teeth were analyzed for optimal adaptation (Figure 2). Of the 22 prototypes, a range of only 3 posts were deemed adequate for endodontically treated teeth in adult dentition. The properties of the quartz fiber/epoxy material demonstrated superior post-to-canal adaptation, which ensured the biomechanical performance of the coronal restorations. The shape and dimensions of these posts are illustrated in Figure 3.

This DT Post system consists of 3 post sizes at the apex: ISO 90, 100, and 120. The apical 5 mm of all 3 sizes retains the appropriate 2° taper. The middle section of the post increases in taper and diameter from post No. 1 to No. 3.
- DT Post No. 1 (smallest; ISO 90-06°) is best suited for smaller canals, premolars, molars, and lower incisors.
- DT Post No. 2 (ISO 100-08°) properly fits most maxillary laterals, and upper and lower cuspids.
- DT Post No. 3 (largest; ISO 120-10°) is best for use in the palatal root of maxillary molars, distal canals in mandibular molars, and upper centrals and canines.

Table 1 offers recommendations for the post sizes in relation to tooth category. Despite these statistical implications and clinical suggestions, clinical judgment and experience are the best guide to post size selection.

An ongoing clinical study designed to evaluate the long-term performance of the DT Post is currently in progress. Twenty clinical instructors at the fixed prosthodontic and endodontic divisions of Université de Montréal as well as third and fourth year undergraduate dental students have been using the DT Post system according to an established protocol since September 1999. Approximately 30% of remaining tooth structure has been chosen as a standard requirement for use of this post. Currently, 382 of these posts have been placed and initial follow-up is promising.

Esthetic Requirements

The increasing demand for more esthetic materials has resulted in the introduction of all-ceramic systems. Unfortunately, although these all-ceramic crowns are esthetic and translucent, their appearance can be readily compromised by the color of an underlying post, carbon fiber, or metal.

According to Vichi and colleagues, a minimum of 2 mm of IPS Empress® is required to mask out the potential color influence of a dark post. The DT Post system is constructed with quartz fibers (instead of carbon), which allow light to diffuse without interference and without the apparent shading of the core through the crown.

This quartz fiber/epoxy post is available in both translucent (DT Light-Post™) and off-white (DT White-Post™) versions. The choice

1Ivoclar Williams, Amherst, NY 14228; (800) 533-6825
between the translucent and off-white is primarily one of technique. Dentists who prefer a light-cure technique may choose the DT Light-Post™. Those dentists more confident using a chemical-cured or dual-cured adhesive and cement may select the DT White-Post™.

Case One

A 24-year-old woman presented with deteriorated crowns on teeth Nos. 8 and 9 (Figure 4A). Tooth No. 8 had also been endodontically treated (Figure 4B), and approximately half of the coronal hard tissue remained.

Canal Instrumentation

The gutta percha was removed by softening it with a heat carrier followed by using a universal drill, which is provided with the system. Approximately 5 mm of gutta percha was left to preserve the apical seal. The DT Post drills were positioned over a postendodontic periapical radiograph of tooth No. 8 to determine the most appropriate drill size for removing the remaining gutta percha.

The drilling sequence of the canal was performed by gradually increasing the size of the drill: drill No. 1 was used first, followed by No. 2. Canal preparation was finished using drill size No. 3 (120-10). An additional periapical radiograph was made to confirm complete removal of the gutta percha from the canal walls. The canal preparation now resembled a double taper shape to provide near ideal apical (taper 02°) and coronal (taper 10°) post adaptation (Figure 4C). Complete seating of a No. 3 post was verified with a quick try-in. The length of the post may be adjusted by cutting the coronal extension with a diamond disc before or after post cementation or core build-up with diamond burs (never use scissors or shears to adjust the post length).

Post Cementation

The post was swabbed with alcohol to remove contaminants. A light-cured primer/adhesive resin was painted on the post to ensure proper wetting of the surface. The surface was then gently air-dried and light-cured for 15 seconds. The canal and surrounding tooth structure were etched for 15 seconds.
with 37% phosphoric acid and thoroughly rinsed. Excess water was removed with absorbent points (rather than air spray) to avoid overdrying the dentin. Moist dentin is essential for proper wetting with the primer/adhesive resin.

All dentin received two coats of adhesive using a saturated absorbent point or a micro-brush. Excess resin should be removed with a clean absorbent point to avoid pooling at the apex of the canal and impeding insertion or fit. The adhesive was sprayed with a gentle air stream to evaporate the solvents and then light-cured for 15 seconds. The base and catalyst of a dual-curing system were mixed together and the canal was filled with a Centrix syringe and Accudose needle tip (a lentulo can also be used). Because voids and porosities can be introduced in the cement during manipulation, injection of the cement represents an expedient approach for filling the canal and minimizes potential air bubble incorporation. The No. 3 translucent post was inserted into the canal, held in position, and light-cured for 30 seconds (Figure 4D). Data on light transmission through the translucent post indicates that most commercially available dual-cure cements will polymerize within the canal after 30 to 60 seconds of exposure (600mW/cm²). These cements have different polymerizing potential when light-curing conditions are not optimal.3 These findings suggest that caution should be used when choosing a dual-cure cement. Their potential to fully cure without light varies and it should be verified before luting the post.

The core build-up was performed using a light-cured composite resin (Figure 4E) followed by tooth preparation (Figure 4F). Impression and temporization were achieved at the same appointment. Two IPS Empress® crowns were inserted at a subsequent appointment (Figure 4G). Postoperative radiography confirmed a good post to canal adaptation (Figure 4H).

Case Two
A 22-year-old woman presented with fractured central incisors (Figure 5A). Tooth No. 9
had been previously endodontically treated (Figure 5B). Canal instrumentation and post cementation were performed using the same technique described in the first case.

Light-curing cements are contraindicated with the off-white post because the light cannot transmit through the white quartz fiber/epoxy post (Figure 5C). Self-curing cements are highly recommended for this type of post. The core build-up was fabricated with a light-cured composite resin followed by conventional tooth preparation (Figure 5D). Impression and temporization of tooth No. 8 were achieved at the same appointment. A Procera® crown was cemented at a later appointment (Figure 5E). The periapical radiograph confirmed a good approximation of the post to the canal walls (Figure 5F).

Conclusion

The ideal endodontic post should provide secure attachment of the core and crown without interfering with delicate color and shading illusions. It should also allow conservative preparation and close adaptation over the

*Nobel BioCare USA, Yorba Linda, CA 92887; (800) 891-9191
largest possible surface area, while decreasing the probability of root damage.

The DT Post design offers better adaptation of the post to endodontically treated canals without compromising the esthetics of the final restoration. The specific tapers incorporated into the post design capitalize on the demonstrable mechanical properties of the post through a natural fit. Furthermore, the use of a less rigid material, such as quartz fiber/epoxy, reduces the incidence of root fracture.

Additional long-term controlled clinical studies are needed to confirm clinical success with variable levels of coronal tooth destruction.

Disclosure

The University of Montreal has received support from RTD for research.

References

20. Petrova Y: Canal adaptation of various dimensions of a double taper post in endodontically treated teeth. Supervised project, Université de Montréal, Québec, Canada, 1999.