CE 2

Six Years of in vitro/in vivo Experience With Composipost™

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Abstract

Some years ago, we created the following classifications for endodontic posts: (1) first generation posts (self-threaded posts, screw posts, serrated-carved posts); (2) second generation posts (passive posts); (3) third generation posts (nonmetallic passive posts). In this last group, we the placed carbon-fiber posts, which have a modulus of elasticity very similar to the modulus of elasticity of dentine and can realize a tooth-post-core monobloc instead of an assemblage of heterogeneous materials. This is quite a new philosophy in rebuilding endodontically treated teeth and is based on the use of integratable materials that homogeneously distribute masticatory loads and reduce stress.

Learning Objectives

After reading this article the reader should be able to:

- discuss the philosophy of rebuilding endodontically treated teeth.
- explain the difference between first-, second-, and third-generation posts.
- describe how to remove the smear layer from a root canal by total etching with 32% orthophosphoric acid.
- discuss the clinical results of a 6-year study of 350 preprosthetic rebuildings.

More than 6 years ago, we began to use Composipost™[,a], known in the United States as C-POST™, a revolutionary new endodontic carbon-fiber post that was invented by Duret in 1988.[1]

This post won our attention for two reasons. The first was that it has good biomechanical characteristics. Composipost™ is a cylindrical, parallel-sided post, with two different diameters. This design permits less dentine sacrifice and double support at the apex, which greatly reduces stress. Its tensile strength is 1,400 MPa to 1,600 MPa; flexural strength is 1,400 MPa to 1,700 MPa; and compressive strength is 440 MPa. The resistance to side-applied forces is low, 75 MPa to 80 MPa; however, this is not a disadvantage because the possibility of detaching carbon fibers from the resinous matrix makes an endodontic re-treatment easier.[2,3]

The second reason we chose it is that it has the potential to obtain a tooth-post-core monobloc instead of an assemblage of heterogeneous materials. In fact, with metal posts, the following different materials are combined: post (titanium, steel, or gold-plated brass); cement (usually zinc-phosphate); and an amalgam core. With Composipost™, we use a post (carbon fibers in resinous matrix, Figure 1); cement (composite cement); and a composite core. These materials have the same coefficient or modulus of elasticity, which is very close to the coefficient of elasticity of dentine. For this reason, masticatory stress absorbed by homogeneous materials is also distributed homogeneously, protecting the tooth from tooth fracture or post dislodgment. With Composipost™, no isochromatic bands are found in photoelastic tests. On the other hand, many metal threaded posts

[a] RTD, Grenoble, France; distributed in the US by BISCO Dental Products, Itasca, IL 60143

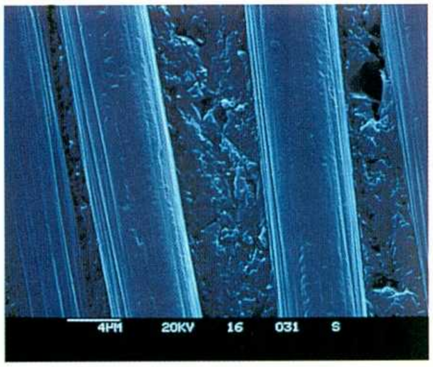

Figure 1—SEM of carbon fibers in a resinous matrix (X4000).

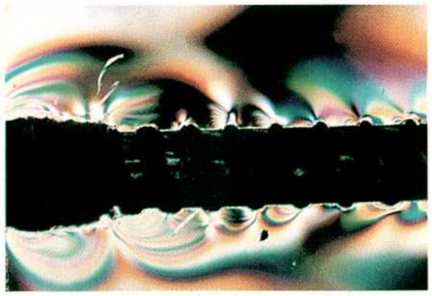

Figure 2—Photoelastic test with metal threaded post (Flexi-Post®). The isochromatic bands are very clear, close, and intensely colored, particularly where threads are placed under great stress.

tend to show very close and intensely colored bands that are indicative of great stress, particularly where the threads are placed (Figure 2). The carbon-fiber post, therefore, is quite different from the metal post. We call the Composipost™ a "nonpost" because, although it looks and is used like a post, from a biomechanical point of view, it is more similar to an endodontic extension of a composite-made core, the basic difference being that carbon fibers prevent resin fracture.

We used an Instron machine[b] to evaluate this post for mechanical resistance and, especially, tensile strength. We also made observations with scanning electron microscopy (SEM). The purpose of these studies was to identify the relationship between the post and various luting cements and, consequently, differences in retention. In the same period, we used posts in several different clinical situations. We started rebuilding anterior teeth, subjected to less masticatory load, and successively extended clinical use to posterior teeth in single preprosthetic cores. Finally, we used it to rebuild cores in complex prosthetic rehabilitations. The good clinical results we had led to our nearly exclusive use of Composipost™ in our practice as a substitute for titanium or steel prefabricated posts, as well as for gold-made post and cores. We began by using Standard Composipost™, then later experimented with Composipost™ "Retentive,"[a] which has circumferential grooves on the surface that provide mechanical retention. Recently, we received the Endo•Composipost™,[c], designed at Montreal University, which has a distinctive conical profile that makes it suitable for the distal roots of mandibular molar teeth. In total, we present 350 treatments that have been followed for at least 6 years.

[b] Instron Corp, Canton, MA 02021

Table 1—Tensile Strength Tests With an Instron Machine

First Group

- Standard Composipost™, middle diameter, 8-mm deep in root-canal space
- Post surface treated with silane
- Wall pretreated with EDTA + NaOCl
- Passive cementation with Boston Post™ cement
- Tooth surface etched with 10% orthophosphoric acid and bonded, without adhesive

Value of retention (Instron) **65.7 kg**

Second Group

- Standard Composipost™, small diameter, 8-mm deep in root-canal space
- Post surface treated with silane
- Same wall pretreatment; same passive cementation
- Same etching and bonding with adhesive

Value of retention (Instron) **76.5 kg**

Third Group

- Standard Composipost™, medium diameter, 8-mm deep in root-canal space
- Post surface treated with silane
- Same wall pretreatment; same passive cementation
- Same etching procedure; bonding with dental adhesive

Value of retention (Instron) **84.7 kg**

In Vitro Research

Composipost™ Standard was first subjected to tensile tests, with forces applied longitudinally by an Instron machine. Twelve extracted maxillary canine and incisal teeth were prepared after endodontic treatment and Composiposts™ were luted 7 mm deep in the root canal. In all cases, the luting cement used was Boston Post™,[d] cement, and the chemical pretreatment of the wall was performed with ethylenediaminetetraacetic acid (EDTA) and sodium hypochlorite (NaOCl). The surfaces of six posts were silanated. The medium retention value was 29.5 kg for Composipost™ without silane and 38.5 kg with silane. This last value is not bad for a

[c] Biodent, Laval, Quebec, Canada H7W2Z1
[d] Roydent Dental Products, Rochester, MI 48309

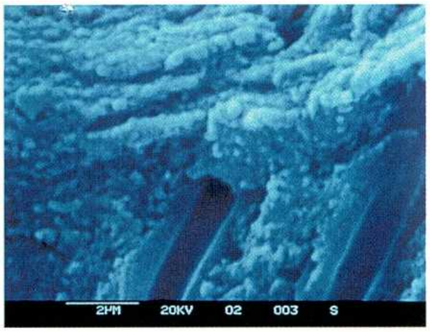

Figure 3—Smear layer, which covers and obstructs dentinal tubules. EDTA + NaOCl only removes the smear layer and opens the dentinal tubules (SEM, X2500).

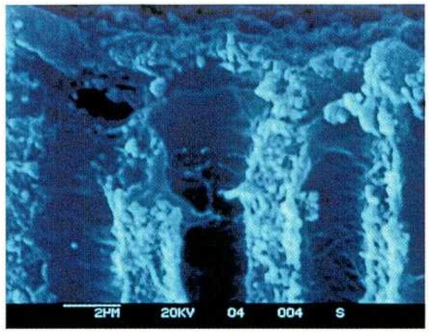

Figure 4—Total etching with 32% orthophosphoric acid removes the smear layer and opens dentinal tubules, but also enlarges the first tract of the tubules and denudes the collagenic fibers (SEM, X2500).

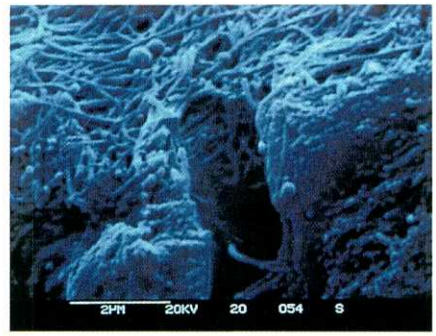

Figure 5—The denuded collagenic fibers are collapsed under the action of the acid. (SEM, X2500).

nonthreaded post with a smooth surface; for example, a ParaPost®,[e] of the same length luted with zinc oxide cement has a retention value of about 30 kg, according to Deutsch in 1985.[4,5] Test results showed that surface pretreatment with silane can increase retention.

However, we soon realized there was a conceptual error in our procedures. The metal post plus amalgam core is very different from the Composipost™ plus rebuilt core with composite resin. In the first case, traction applied directly on the post or indirectly on the amalgam core gives the same result because amalgam has no adhesive properties. On the contrary, composite is used after etching and bonding, and it causes an effective adhesion increase. Dental adhesives, such as ALL-BOND® 2[a], demonstrate adhesion capability well over 20 MPa. For in vitro tests to have a realistic clinical relationship, we must reproduce the clinical situation. Tractional forces were thus applied on the resin core rather than on the post. Consequently, we made a new series of tractional tests based on this different operational approach.[6,7] We used a total of 30 maxillary canine and incisal teeth, extracted and endodontically treated, in three groups of 10 each. The parameters and results are listed in Table 1.

[e] Coltene/Whaledent, Mahwah, NJ 07430

Two considerations became immediately apparent:

1. Rebuilding with composite on a carbon-fiber post, after etching and bonding, yields a high increase in retention. If an adhesive is used, retention increases more. This doubles the retention of the single post.
2. Increased diameter results in an increase in retention; this does not occur with metal posts.

After those initial findings, we conducted similar tests using different cements—Sealbond[f] and Flexi-Flow®,[g]. Surprisingly, there was a little decrease in retention seen with both Sealbond (71 kg) and Flexi-Flow® (72 kg) when used with a small-diameter Standard Composipost™. Similarly, when using two Standard Composiposts™ in an extracted premolar tooth with two canals, there was no retention increase (75 kg). Deductively, for this kind of experimental procedure (Standard Composipost™, surface treatment with silane, removal of smear layer with EDTA + NaOCl, three types of composite cements), we obtained a retention value rating ranging from 70 kg to 80 kg. Yielding always occurs at the post-cement junction; the post comes out of the canal with little cement remaining on the surface. To effect retention increase, the procedure must be changed. It is possible to operate with: (1) a different chemical treatment of dentine in the endodontic wall; (2) a different post-surface treatment; and (3) a different post profile.

Table 2—Traction Testing After Different Post-Surface Treatments

No treatment	302 N
Surface treated with acetone	310 N
Surface treated with silane	420 N
Surface treated with Primer B	580 N

Endodontic Wall

Instead of using EDTA + NaOCl, we used total etching with 32% orthophosphoric acid. The EDTA + NaOCl only removes the smear layer and opens the dentinal tubules (Figure 3). Using 32% orthophosphoric acid not only removes the smear layer and opens the tubules, but also decalcifies and enlarges the tubules' first tract. It therefore denudes the collagenic fibers and allows a res-

[f] RTD, Grenoble, France (not available in the United States)

[g] Essential Dental Systems, Inc, South Hackensack, NJ 07606

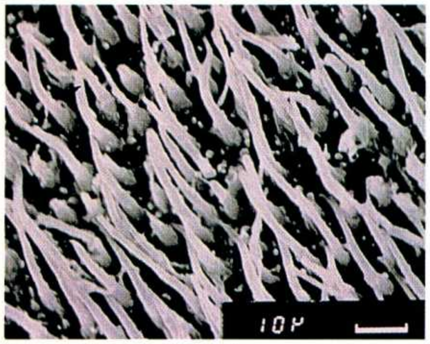

Figure 6—By using primers, we draw up collagenic fibers and allow the resinous bonding agent to impregnate the fibers and create a hybrid layer (SEM, X2500).

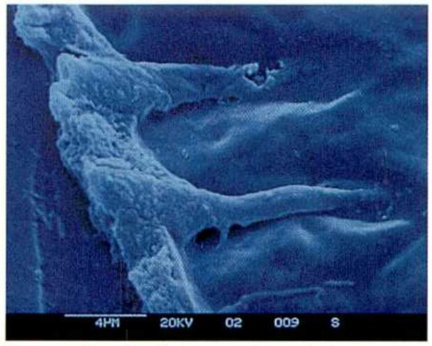

Figure 7—Resin tags depart from the hybrid layer and deeply penetrate into dentinal tubules (SEM, X2500).

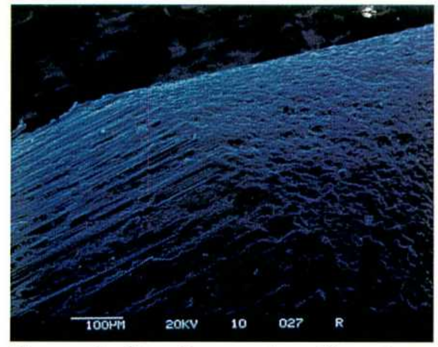

Figure 8—The Composipost™ surface, nontreated (SEM, X150).

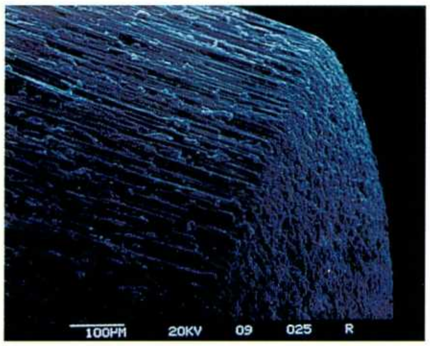

Figure 9—The Composipost™ surface, treated with acetone. There are no really significant differences (SEM, X150).

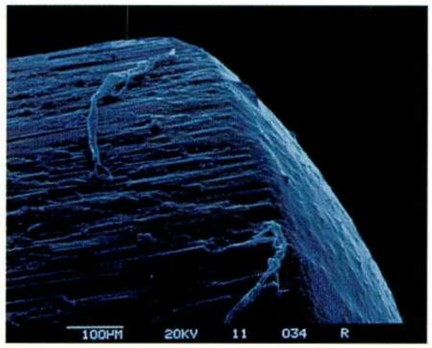

Figure 10—The Composipost™ surface, treated with silane. The surface shows a less irregular appearance and silane seems to give a little coverage of the post (SEM, X150).

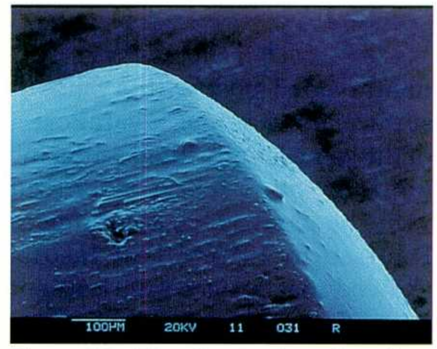

Figure 11—The Composipost™ surface treated with ALL-BOND® 2 Adhesive System Primer B. The surface is very smooth, fully covered, and impregnated by a thin primer layer that is impossible to divide from the resinous matrix of the Composipost™ (SEM, X150).

inous bonding agent to impregnate the fibers, which creates the well-known "hybrid layer" of dentine-composite (Figures 4 through 7). We find that not all the adhesives deeply penetrate open tubules (for example, Flexi-Flow® does not and ALL-BOND® 2[a] Universal adhesive plus BISCO C & B™[a] cement may).

This results in an increase of the retention capability of all composite cements that create a hybrid layer.

Post-Surface Treatment

Instead of treating the surface with silane, we used Primer B from the ALL-BOND® 2 Universal Adhesive System. We compared treating the surface with silane, Primer B, and acetone, and studied it in two different ways:

1. SEM observation: We used a nontreated Composipost™ as a test (Figure 8). The surface treated with acetone looks slightly more irregular, but there are no highly significant differences (Figure 9). The surface treated with silane shows a less irregular appearance; silane seems to result in light coverage of the post (Figure 10). The surface treated with Primer B (ALL-BOND® 2) is very smooth, fully covered, and impregnated with a thin primer layer that is impossible to divide from the resinous matrix of the Composipost™ (Figure 11).

2. Traction tests (Instron): We divided 20 Composiposts™ into 4 groups of 5 each (no treatment, surface treatment with acetone, with silane, and with ALL-BOND® 2 Primer B). A 5-mm-high cylinder was built with composite around each Composipost™. The cylinders were formed with a mold and were exactly alike. The average results of traction with the Instron machine are listed in Table 2.

The SEM and Instron tests demonstrate that surface treatment with ALL-BOND® 2 Primer B effectively increases retention of the Composipost™ in the root canal. Successive composite-luting cement becomes attached to the thin primer layer, giving a stronger composite-to-cement adhesion.

Based on these points, a new series of tests was conducted to demonstrate total etching in the canal preparation; use of ALL- BOND® 2 adhesive plus BISCO C & B™ cement to lute the post; and use of Standard Composipost™, middle diameter, with Primer B surface treatment.

We obtained the following result: with the use of Standard Composipost™, the average retention value was 98 kg. There is a clear increase compared with the use of other chemical root-canal treatments (EDTA + NaOCl), sur-

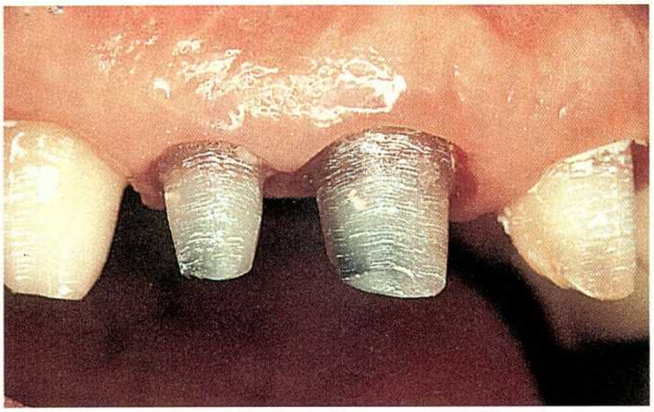

Figure 12A—Front view of maxillary incisors, rebuilt with Composipost™.

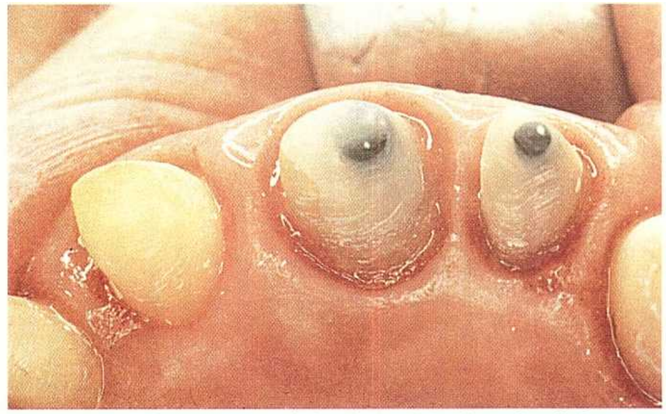

Figure 12B—The same teeth in Figure 12A, in palatal view.

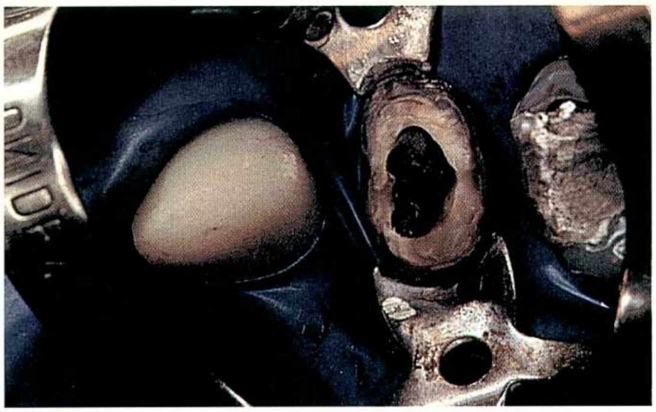

Figure 13—Maxillary premolar with two canals and two small-diameter Composiposts™.

Figure 14—A mandibular premolar in which a middle-diameter Composipost™ has been cemented.

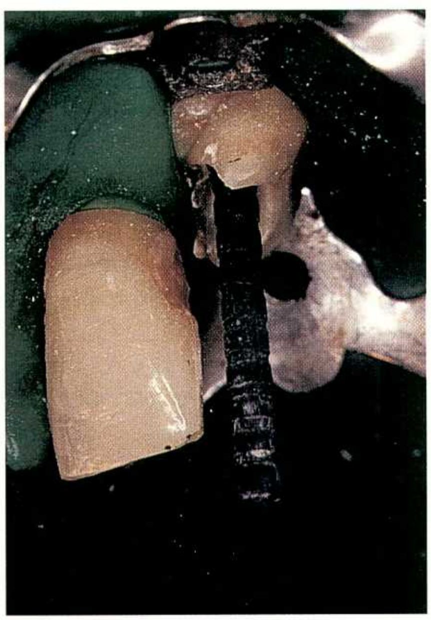

Figure 15—A maxillary incisor, in which a Composipost™ Retentive has been cemented.

Table 3—Subdivisions of the Three Major Categories of Composiposts™

Category	Number of Cases
Standard Composipost™	252
Composipost™ Retentive	78
Endo•Composipost™	20
Breakdown	
Single preprosthetic rebuilding	231
Maxillary incisal teeth (Figures 12A and 12B)	72
Mandibular incisal teeth	19
Canine (total)	30
Maxillary premolars (Figure 13)	42
Mandibular premolars (Figure 14)	33
Maxillary molars	15
Mandibular molars	20
Rebuilding in complex prosthetic dentistry (bridges, etc)	119 cases
Incisal teeth	41
Canine teeth	30
Premolar teeth	37
Molar teeth	11

Figure 16—A first mandibular molar. The new tapered Endo•Composipost™ has been cemented in the distal root canal.

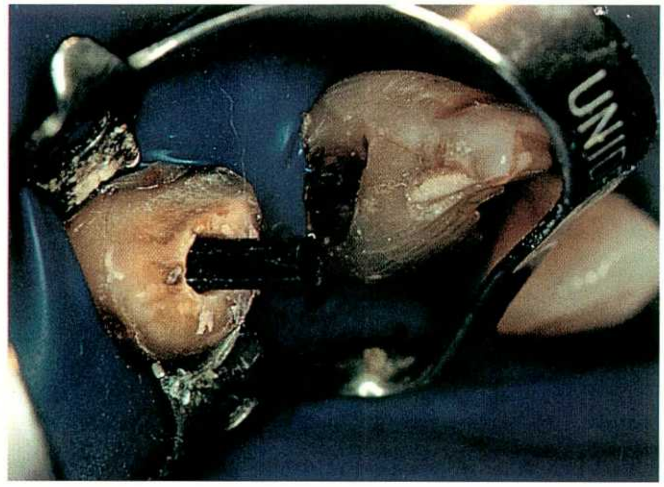

Figure 17—To rebuild maxillary incisor teeth in older patients, a middle-diameter Composipost™ is used.

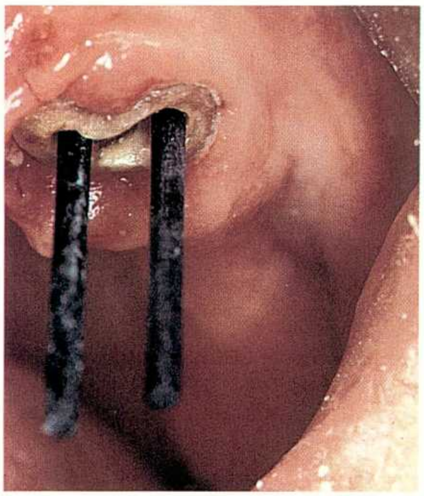

Figure 18—In a fractured, previously endodontically treated maxillary premolar, two small-diameter Composiposts™ are being tried-in.

face treatment with silane, and the use of Boston Post™ cement as a luting material (84.7 kg).

Post Profile

Different post shapes may add a mechanical retention to adhesive retention. This is the case of Composipost™ Retentive, which has the same properties as the standard form with the exception of the circular grooves on the surface (Figures 12A and 12B). With the use of Composipost™ Retentive, there was no dislodgment of the post, but root fractures occurred at an average tractional force of 127 kg. This is the greatest retention value ever recorded in the literature with the use of passive posts. This value is equivalent to, or, in many cases, superior to, the retention capability of some metal threaded posts of the same length (Flexi-Post®[g], Kurer® Anchor[h]), and more than double the value compared with other threaded posts (Radix Anker[i], 60 kg, according to Deutsch, 1985). If the purpose of threads is to offer higher retention, these results may demonstrate the possibility of obtaining the same or superior effects with passive posts. These are fully atraumatic, with no risk of dentine damage or stress.

Clinical Results

Our clinical experience amounts to 350 preprosthetic rebuildings subdivided into the following categories: (1) Standard Composipost™, 252 cases; (2) Composipost™ Retentive, 78 cases; and (3) Endo•Composipost™, 20 mandibular cases. These three categories can be further subdivided (Table 3).

In 27 cases of complex prosthetic rehabilitation, teeth rebuilt with Composipost™ plus composite core formed a bridge pillar following the California Bridge prosthetic technique. We have used this technique in nearly 300 cases.

[h] Teledyne Water Pik, Fort Collins, CO 80553

[i] Maillefer Instruments, Switzerland

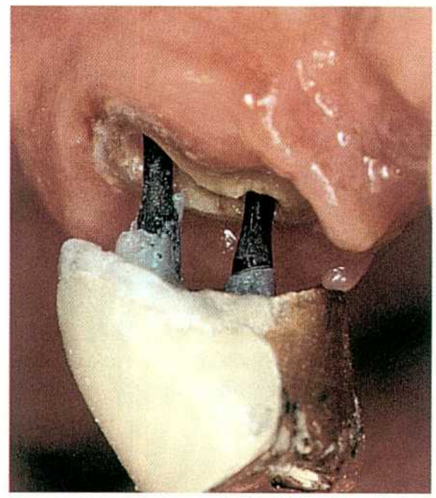

Figure 19—Posts are suitably cut and the crown is resin-rebased. The resulting post-and-core monobloc crown is passively cemented in root canals.

The Composipost™ Retentive (Figures 13 through 15) was used in 78 cases and Endo•Composipost™ was used in 20 cases, always placed in the mandibular first molars (Figures 16 and 17). All rebuilt restorations were performed under rubber dams, except for some cases of "emergency rebuilds," where using a rubber dam was not possible. In most of the rebuilds, we used step-by-step, light-curing composite. Recently, we started using self-curing composite, with a copper band as the matrix and an injector instrument to avoid creating air bubbles or filling defects. Only one failure occurred, which resulted from immediate post dislodgment. There were no failures resulting from post or root fracture. The authors consider 1 failure in 350 treatments to be an excellent in vivo result.

Clinical Considerations

The failure recorded as a result of post dislodgment involved a Standard Composipost™ luted with Flexi-Flow® cement that was removed from the canal, removing an immediate temporary resin crown in the process. We cannot exclude the possibility of a defect in the chemical treatment of the dentinal wall that would have resulted in a permanent smear layer. A defect in the polymerization of composite cement also may have occurred, which has been noted before with the use of Flexi-Flow® cement. Mechanical canal preparation was repeated, slightly enlarging space to remove the first few microns of the dentinal tubules, probably filled by endodontic cement or gutta-percha. No further post dislodgment has so far been reported.

A single post dislodgment resulting from cementation failure may demonstrate that in standard operative conditions, differences between Standard and Retentive Composipost™ are not significant, especially if the post length is 9 mm. If post length is shorter (note: we cautiously accept post lengths of less than 7 mm), Composipost™ Retentive must be used.

Endo•Composipost™ is especially indicated for use in the distal roots of mandibular molars, which usually have a slightly conical profile. Loss of retention, usually associated with conical posts, is not very important in molars, where endodontic pins in the first 2.5 mm of mesial canals are usually excavated.

Many cases involved patients older than 70 years of age (Figure 17). Composipost™ may be the material of choice for rebuilds for older patients because: (a) there is very often vertical bone loss in the elderly, which may modify the periodontal status of the tooth. Use of Finite Element Analysis, with its computer patterns, has demonstrated some problems with using metal posts. Creation of a tooth-post-core monobloc, which the carbon-fiber posts exhibit, makes vertical bone loss much less influential; (b) for older patients, it is preferred to have one-session treatments to avoid the difficulties of movement or transport, and the C-Post™ can be finished in one appointment; (c) lower cost. A composite post and core built with Composipost™ in one session is less expensive than a gold post and core.

Seven of the rebuilds were performed under emergency circumstances. In all seven cases, fracture of the core and prosthetic crown had occurred. In two cases, it was a single crown, and in five cases, the crown was part of complex prosthetic rehabilitation (fixed in one case, removable in four cases).

The treatment is quite simple: adapt the length of the Composipost™ and rebase the crown with resin (Figures 18 and 19) to obtain a modified Richmond crown. The modified Richmond crown is passively luted in the root canal with composite cement. A removable prosthesis can then be connected to the new special crown.

We consider this treatment a temporary measure; however, one of these has been in situ for 4.5 years and another for 3.8 years without any problems.

Conclusion

Composipost™ demonstrates very good biomechanical characteristics and permits the creation of a tooth-post-core monobloc instead of an assemblage of heterogeneous materials in rebuilding endodontically treated teeth. Moreover, it is passively cemented in the root canal, is fully atraumatic, and has very high retention. Finally, Composiposts™ permit one-session treatment and are less expensive than gold posts and cores. So far, clinical results indicate that it may be the post of choice in many cases.

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