

A retrospective study of 236 patients with teeth restored by carbon fiber-reinforced epoxy resin posts

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Statement of problem. The Composipost dowel is made of stretched, aligned carbon fibers embedded in an epoxy-resin matrix. It is widely used in Europe and Canada for the restoration of endodontically treated teeth and was introduced in the United States 2 years ago as the C-Post dowel.

Purpose. This retrospective study evaluated treatment outcome of the Composipost system after 2 to 3 years.

Material and methods. A total of 236 patients treated during a 1-year period by seven Swedish dental practitioners were included. Of those, 146 patients consented and data were collected from the dental records of the remaining patients. Thus, the material comprised 236 teeth restored with carbon fiber-reinforced epoxy resin post, 130 maxillary and 106 mandibular teeth, with a mean restoration time of 32 months (range 27 to 41). Periodontal conditions, radiographic signs, and prosthodontic results were recorded.

Results. Five teeth (2%) had been extracted for reasons unrelated to the Composipost system. Periodontal conditions such as plaque accumulation, gingival health, bleeding on probing, and pocket depth around the teeth with Composipost dowels were similar to the control teeth. No dislodgment or root or post fractures were observed clinically or on radiographs. Radiographic examination of bone height measured from the apex to the bone margin mesially and distally showed differences on the mesial side but not on the distal surface ($p < 0.05$) between the Composipost-treated teeth and the controls.

Conclusions. Promising results after 2 to 3 years of clinical service indicate that this system can be a viable alternative to conventional post-and-core systems. (J Prosthet Dent 1998;80:151-7.)

CLINICAL IMPLICATIONS

The carbon fiber post offers a resilient, highly retentive method with uninterrupted bonding between the tooth through the post and the core. The Composipost system seems to be a promising alternative to conventional cast metallic posts.

Final restoration of endodontically treated teeth often requires a post and core. Space for the post is obtained by removing a predetermined amount of root canal filling material and then preparing the canal with reamers or drills to the desired form and shape. Conventional restorative materials are a cast metal post and core, or a prefabricated metal post with a silver amalgam or composite core. However, there are some disadvantages associated with conventional post-and-core systems such as poor retention of the post, potential for post and root fractures, and risk of corrosion when different metals are used in the system.¹⁻³

Parallel-sided, threaded posts offer the greatest resistance to dislodgment from the root.⁴⁻⁶ Cemented, parallel-sided posts have been found to be more retentive than cemented tapered posts.⁵⁻⁸ A longer post pro-

vides greater retention than a shorter one, but over-preparation of the canal increases the risk of root perforation or of disturbing the apical endodontic seal. Because of the root anatomy, there may also be an increased risk of root perforation when the root is prepared for a parallel-sided post.

Weine et al.⁹ and Bergman et al.¹⁰ reported no retention problems in their retrospective evaluation of cemented, tapered posts over 10 years or more. However, in an analysis of 788 posts 4 to 5 years after cementation, Torbjörner et al.¹¹ reported a significantly higher success rate for parallel-sided serrated posts than for custom-cast posts.

The influence of different cements on retention of posts has been the subject of recent research.^{4,5,12,13} There are conflicting reports on the ability of metal posts to reinforce endodontically treated teeth.^{14,15} There is also controversy over the effects of metal corrosion on the integrity of the root and the periodontium.¹⁵⁻¹⁸

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Fig. 1. One carbon-fiber post. Arrows indicate two stabilization stages aimed to distribute stress. Height of conical seating face is 1 mm.

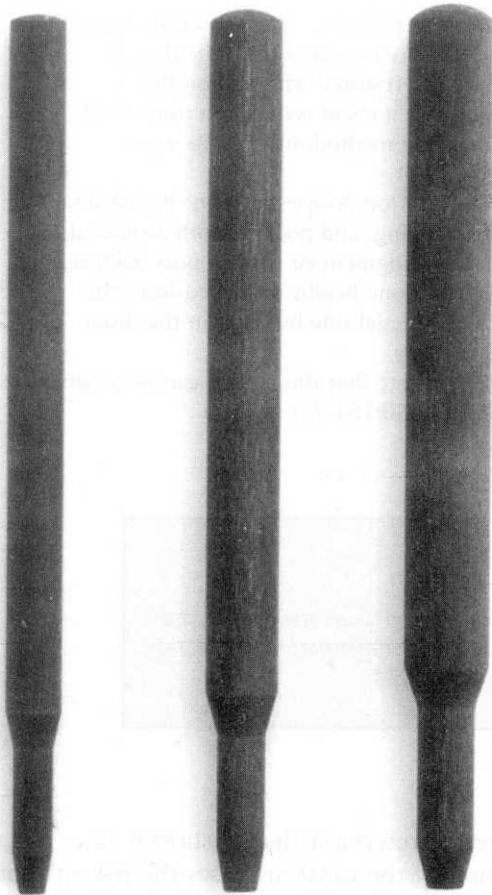


Fig. 2. Three carbon-fiber posts of upper shank diameters 1.4 mm, 1.8 mm, and 2.1 mm and lower shank diameters of 1.0 mm, 1.2 mm and 1.4 mm. All posts have same overall length of 22 mm.

In 1990, Duret et al.¹⁹ introduced a nonmetallic material for the fabrication of posts, based on the carbon fiber reinforcement principle. This new endodontic post-and-core system, Composipost (Recherches Techniques Dentaires [RTD], Meylan, France), has been used by dentists in Europe and Canada for 7 years. It was introduced in the United States 2 years ago as C-Post dowel. The Composipost dowel is made of equally stretched and aligned carbon fibers, solidly attached to a special matrix of epoxy resin. The interface between the carbon filaments and the matrix is an

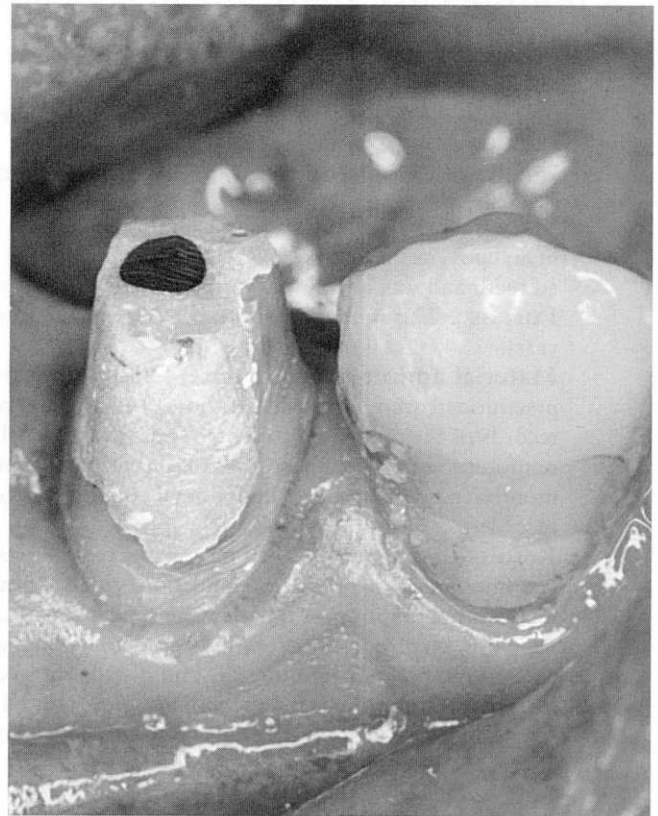


Fig. 3. Buccal view of completed core build-up over post on mandibular second premolar.

organic composition. The carbon fibers, by exerting uniform tension on the filaments, impart high strength to the posts. The Composipost dowel has a cylindrical shape, and it tapers into two conical-shaped seating faces of different diameters for stability. The height of the conical seating face is 1 mm (Fig. 1). Posts are available with upper shank in diameters of 1.4, 1.8, and 2.1 mm and lower shank diameters of 1.0, 1.2, and 1.4 mm. All posts have the same overall length of 22 mm (Fig. 2).

Composipost dowels are passive and are designed to be used with a bonding technique. The recommended core material is Resilient composite (Recherches Techniques Dentaires [RTD]), a BIS-GMA resin filled with short glass fibers. Boston Post or Sticky Post resin cements (RTD) were used previously for bonding. They are now replaced by a new bonding system, which is a radiopaque composite dual cure cement associated with a primer such as Allbond 2 (Bisco Dental Products, Itasca, Ill.). It provides high bonding strength and a hybrid layer. Figure 3 illustrates a completed core reconstruction over a post, and Figure 4 is a radiograph of a maxillary first premolar restored with a Composipost system. This procedure has recently been described and illustrated in detail.^{20,21} Furthermore, clinical procedures for Composipost dowels are less

time-consuming and expensive than conventional procedures for cast metal posts.

According to the manufacturer, the tensile strength of the Composipost dowel is 1600 MPa. By comparison, the values for other prefabricated metallic post-and-core systems can vary from 654 to 114 MPa.²² The average modulus of elasticity is 21 GPa, according to the manufacturer. It has been suggested that a post should have a modulus of elasticity similar to dentin for more uniform distribution of forces along the length of the post.^{23,24} In a recent study of dry stored Composipost dowels, Torbjörner et al.²⁵ reported values of flexural modulus and ultimate flexural strength as 82 ± 6 GPa and 1154 ± 65 MPa, respectively. Storage in water significantly decreased both flexural modulus and strength for the Composipost dowels with 40% and 30%, respectively ($p < 0.001$). Fatigue test resulted in an additional significant reduction of flexural modulus and strength for both the dry and the water saturated posts ($p < 0.001$). The stress/strain curves for dry and wet stored Composipost dowels, with and without proceeding thermocycling, showed all a linear elastic portion, followed by a large plastic yield. At higher loads, bundles of fibers fractured but a complete fracture of the post did not occur within the limits of the test. As the material is being widely used, further studies are necessary, including investigations of possible failure mechanisms in the intraoral environment, and clinical long-term studies to evaluate the life-span claimed by the authors.²⁵

In another recent study, 14 bovine teeth restored with Composipost dowels and composite cores and covered by metal crowns were submitted to a fatigue cycle loading up to 260,000 cycles.²⁶ Teeth with prefabricated carbon fiber posts had significantly higher resistance to intermittent loading than those with prefabricated parallel-sided titanium posts (Para-Post) or tapered, individual cast posts, as determined in another study.²⁷ None of the restored bovine teeth failed as a result of complete dislodgment of the crowns or posts or fracture of the posts. After loading was discontinued, 4 of the restored teeth were found to have longitudinal incomplete macroscopic fractures.²⁷

Cytotoxicity tests of the Composipost dowel reported gave favorable results for the agar overlay method when using mouse fibroblasts cells (L929) and subcutaneous implantation in guinea pigs.²⁵

The Composipost system is new, so there are no long-term studies of clinical performance. The purpose of this study was to conduct a retrospective clinical and radiographic evaluation of the Composipost dowel after 2 to 3 years in service.

MATERIAL AND METHODS

Records from Unident AB in Falkenberg, Sweden, indicated that 40 dentists in Sweden had a great deal of



Fig. 4. Radiograph of maxillary first premolar restored with Composipost system.

experience with the Composipost dowel system since its introduction in 1991; these dentists agreed to contribute to this study. Seven dentists, from five regions in Sweden, were randomly selected to contribute data from patients treated with the Composipost system until July 1993. From each of the seven dentists, 80% of the total number of patients treated with this system were randomly selected by simple randomization with tables of random numbers. For the resultant estimate to fall within three percentage points of the true proportion with 95% confidence, the rate of success when using the Composipost dowel must be between 92% and 98%, and a total of at least 203 patients had to be examined.²⁸ Therefore a total of 236 patients (91 men and 145 women) treated with the Composipost dowel were selected for evaluation. The age of the patients ranged from 31 to 88 years (mean 57 years). From this sample, 146 patients agreed to participate in a clinical examination. Data from the dental records were available at the time of examination and the records correlated well with examinations. As all patients had previously been included in an individual recall program, data were also obtained from the records of the remaining 90 patients who were unable to participate in person. All indisposed patients had visited their dentists in a recall program 3 to 6 months before this examination took part.

The frequency of types of tooth treated is shown in Table I. The length of clinical service of the carbon fiber-reinforced epoxy resin posts is shown in Table II. The final restorations of the treated teeth were metal ceramic restorations (80%), ceramic crowns (10%), and the remainder restored with composite material. Of the opposing occluding teeth, 88% had fixed restorations, 4% were restored with a removable partial denture, 4% occluded with unrestored teeth, and 4% were not in occlusion.

Table I. Distribution of position of 236 Composipost-treated teeth among the same number of reexamined patients. Number of teeth are given

	Central incisors	Lateral incisors	Canines	Premolars	Molars	Total
Maxillae	14	14	11	56	35	130
Mandible	3	2	11	50	40	106

Table II. Distribution of service of posts at the recall examination in September 1995

Age ^a interval (months)	Number of patients
27-29	80
30-32	62
33-35	67
36-41	22
Total	231 ^b

^aThe mean restoration time was 32 months.

^bFive patients were excluded because five teeth were extracted within 2 to 6 months.

Parameters

The rate of success was assessed by clinical and intra-oral radiographic examinations. In the 146 patients examined, 117 contralateral teeth were available as control teeth. As 29 Composipost-treated teeth missed their contralateral, an additional 29 teeth similar in anatomy and jaw position to the post-restored teeth were used as controls. Periodontal conditions were assessed by recording the Plaque Index,²⁹ the Gingival Index,³⁰ the Bleeding Index,³¹ and measuring pocket depth according to Glavind and L e.³²

Two radiographs were taken of each Composipost treated and control tooth, with the long-cone technique and ultraspeed film (Kodak-Path , Chalon-Sur-Saone, France). A modified parallel technique was used. The radiographs were examined with approximately $\times 5$ magnification. Comparisons were made with radiographs taken immediately after treatment. The periodontal bone height was measured mesially and distally, according to Eliasson et al.¹⁸ as the distance from the apex of the root to a point where the lamina dura still retains its normal width of the periodontal space. All measurements were made with an electronic digitizer on-line with a computer (Accu Grid, Numonics Corp, Montgomeryville, Pa.). The accuracy of the instrument was 0.254 mm according to the manufacturer. The software used was a program for digitizing two-dimensional images (PCDG) (J. McWilliam, written communication, 1988).

The outcome was considered successful if the post and core were in situ, without clinical or radiographic signs of technical failures, loss of retention, root fracture, or post fracture. The clinical examinations, in the practices of the seven dentists, were carried out independently by two calibrated observers. The observers

were not blinded in the clinical examinations as this was not possible. To obtain the maximum unbiased comparison, observers were calibrated. For radiographic registrations, a documented quantitative method was used along with an electronic digitizer on-line with a computer.¹⁸ The radiographs were evaluated at the Department of Prosthetic Dentistry by one observer.

Statistical differences in the clinical and radiographic indices for post-retained and control teeth were analyzed with the Student *t* test for paired samples. The sign test was used for comparisons of the bleeding index values.

RESULTS

The duration of service of the Composipost dowels varied from 27 to 41 months (Table II). Of the total of 236 teeth treated, 5 teeth were extracted within 2 to 6 months because of severe periodontitis in 2 teeth, periapical destruction around one root, and 2 root fractures. All these diagnoses had been noted at the time of post preparation and the restorations were placed as temporary rather than permanent measures. Thus, these failures (2%) were listed as missing teeth. The remaining 98% were classified as successful. The estimated 95% confidence interval for the percentage of success in the population was 96% to 99%.³³

The condition of soft tissues surrounding the post-restored and control teeth is summarized in Tables III and IV. The mean Plaque Index and Gingival Index were 1.0 (SD ± 1.0) and 1.5 (SD ± 1.1), respectively, for post-restored teeth and 1.0 (SD ± 1.0) and 1.3 (SD ± 1.0), respectively, for control teeth. Bleeding on probing was recorded for approximately 50% of sites, but there were no differences between test and control teeth. The mean depths of the post-retained teeth and the control teeth were not significantly different (4.1 mm [SD ± 1.4] and 3.9 [SD ± 1.2], respectively). Periodontal examination indicated a probing depth of more than 4 mm on approximately 14% of the teeth, but the findings were not correlated to the Composipost treatment because dental records and radiographs indicated that these pocket depths were present at the onset of treatment.

No dislodgment or fracture of posts or roots were observed in the remaining 231 teeth. Dental caries was not detected in the post-treated teeth. Thus, no technical failures attributable to the carbon fiber post-and-core system were recorded.

Table III. Mean Plaque Index (PI), mean Gingival Index (GI), and Bleeding Index (BI) (%) of post-restored teeth and control teeth

Variable ^a	Post-restored n = 146 Mean ± SD	Control n = 146 Mean ± SD	Significant test
PI	1.0 ± 1.0	1.0 ± 1.0	n.s.
GI	1.5 ± 1.1	1.3 ± 1.0	n.s.
BI ^b	47% bleeding	45% bleeding	n.s.

n.s., Not significant.

^aMeasurements were performed on all four surfaces and values represent a mean.

^bFisher's test.

A total of 80% of the radiographs showed no pathologic changes. In the remaining 20%, there was non-symptomatic bone destruction of varying severity in the periapical or furcation regions. Mean periodontal bone height for the mesial and distal aspects of Composipost-treated and control teeth is presented in Table V. The bone height mesially of the Composipost-treated teeth was 13.2 ± 0.30 mm (mean ± SEM) as compared with 13.7 ± 0.34 mm of the controls.

The differences between test and control was statistically significant. Distally, the bone height was 11.6 ± 0.27 mm on the post-retained teeth and 12.0 ± 0.31 mm on the control. The differences was not statistically significant.

DISCUSSION

The Composipost system, known as C-Post in the United States, is a new concept for post-and-core restoration of endodontically treated teeth. For optimal results the manufacturer's instructions must be followed carefully. When this system is used, a resin cement is necessary.^{20,25} Resin cements establish a stronger bond to the dentin walls of the root canal after the removal of the smear-layer and application of dentin bonding agents, and to the post itself, thereby increasing the retention of the dowel.²⁰ Excess composite cement, which overflows the access opening during cementation, will bond chemically to the composite core material and integrate the post-and-core unit. The enhanced strength and rapid curing properties of composite cement allow core fabrication and tooth preparation without delay, an advantage over the time-consuming indirect technique for preparing a cast post and core in the laboratory. Adequate dentin must be available for luting, and rubber dam application is highly recommended to obtain the best results.

Another advantage with this system is that the Composipost is rather easy to remove from the root canal. Development of periapical disease may necessitate revision of endodontic treatment. It is easier to remove a carbon post than metal post and core, and less risk of

Table IV. Pocket depth, mean and standard deviation of 146 post-restored teeth and 146 control teeth^a

Pocket depth	Post-restored n = 146	Control n = 146	Significant test
0-4 mm	120	125	n.s.
5 ≥ mm	26	21	n.s.
Mean ± SD	4.1 ± 1.4	3.9 ± 1.2	n.s.

^aPocket depths were measured at four points: mesially, distally, lingually, and buccally. The greatest depth was chosen.

iatrogenic damage because the post material can be drilled out by direct removal (S. Sakkal, written communication 1995). Because of the widespread use of the Composipost dowel in Europe and Canada, an evaluation of the long-term treatment prognosis and possible disadvantages is warranted.

Results from various applied laboratory experiments on the Composipost system, conducted at different research units in dental faculties in Europe, Canada, and the United States, were made available on request from the manufacturer. Clinical follow-up reports were not available, and therefore a retrospective study was conducted.

Of major importance in clinical evaluation of restorative procedures is the selection and size of the sample and the use of well-defined, standardized criteria for evaluation of outcome. There are few clinical studies of post-and-core success and failures. Sorensen and Martinoff³⁴ evaluated 1273 endodontically treated teeth, of which 420 teeth had posts and cores, and 36 teeth (8.6%) had failed as a result of post dislodgments, root fractures, or post perforation. Weine et al.⁹ reported failures in 138 posts and cores (6.5%) after 10 years or more. In a clinical survey of failed post-retained crowns, Lewis and Smith³⁵ concluded that failure of the post crown within 3 years of cementation is more common than later failure. In an analysis of the outcome of two post designs, Torbjörner et al.¹¹ reported a cumulative failure rate of 8.3% over 2 to 3 years. In a 6-year recall study of cast posts and cores at the Student Clinic at the Faculty of Odontology, University of Umeå, Bergman et al.¹⁰ showed a failure rate of 1.56% per year. Mentink et al.³⁶ followed up on 516 teeth restored with cast posts and cores for up to 10 years and found that recementation was the most frequent failure. For anterior teeth, the survival rate was 82%.

In this study of the Composipost dowel, a similar outcome was anticipated. To select a suitable sample size, statistical methods were used to ensure that the results could be compared with those of other studies of metallic posts and cores. Five teeth were classified as unsuccessful but the failures could not be attributed to the Composipost system.

The rate of success was assessed by clinical and intra-

Table V. Periodontal bone height (mm) at mesial and distal aspects of post-restored and control teeth measured on radiographs

	Post-restored <i>n</i> = 146			Control <i>n</i> = 146			Difference mean	<i>t</i> value	<i>p</i> value
	Mean	SEM	SD	Mean	SEM	SD			
Mesial	13.2	0.30	3.62	13.7	0.34	4.11	-0.5	2.05	≤0.043
Distal	11.6	0.27	3.26	12.0	0.31	4.83	-0.4	1.87	≤0.064

Statistical significance was accepted at the level $p < 0.05$.
SEM, Standard error at the mean; SD, standard deviation.

oral radiographic examinations. The periodontal conditions such as plaque accumulation, gingival health, bleeding on probing, and pocket depth around the teeth with the Composipost dowels were similar to the teeth used as control. Radiographic examination of the bone height showed differences on the mesial side of the root but not on the distal between the post-retained teeth and the control, which is in agreement with previous studies.¹⁸ By comparison with the results for metal posts and cores, the clinical performance of the Composipost system after 2 to 3 years is promising. Long-term results are still required.

It is known that endodontically treated teeth present higher risk of biomechanical failure than vital teeth. Caputo and Standlee³⁷ reviewed potential risk factors for failure when different endodontic dowels are used, with regard to choice of material and post design. Until recently, all available prefabricated posts consisted of metal alloys that cause a final heterogeneous combination with the dentine, the metallic post and cement (usually zinc phosphate), and the metallic core. The major disadvantage of these techniques is that the stress can be concentrated in uncontrolled areas that are sometimes vital to the root. Furthermore, there is no adhesion between the zinc phosphate cement and the root structure or any of the restorative materials with which it is used. Technology has produced a rigid non-metallic composite in the form of reinforced carbon fiber that can be formed in various configurations to make maximum use of its properties, and experimental studies have confirmed the value of such material and adhesive techniques^{24,26} to obtain a tooth-post-core monoblock instead of an assemblage of heterogeneous materials. To obtain a high rate of success when this technique is used, adequate dentin must be available for bonding and a ferrule should be incorporated in the design of the dowel.³⁷

Retrospective analysis of the results of clinical performance suggests that the carbon fiber post-and-core system, with mechanical strength similar to that of dentin, has advantages over traditional metallic post-and-core systems. As this is a retrospective study, final conclusions will depend on the results of ongoing prospective multicenter studies.

CONCLUSIONS

In clinical follow-up studies a definition of success should be based on objective criteria. Results of carbon fiber-reinforced resin posts over a period of 2 to 3 years were evaluated in a retrospective study of radiographic, periodontal, and prosthodontic parameters. For the 236 treated teeth evaluated, the following observations were made.

1. Five teeth (2%) had to be extracted as a result of dubious treatment, but failure was not attributable to the Composipost system.

2. There were no differences between treated teeth and the controls with respect to plaque accumulation, gingival health, and pocket probing depth.

3. No post or crown dislodgments or root fractures were recorded. No fracture of any post has been recorded.

4. There were no teeth with pronounced marginal bone resorption and none with post perforation.

Further prospective studies of this treatment are needed for long-term clinical evaluation of outcome.

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