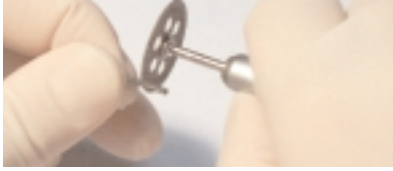


# Rehabilitation of an Endodontically Compromised Tooth with a Carbon Post

Dr. Krasimira Krasteva, DDS



**Fig. 1** Fractured maxillary left lateral incisor previously restored with a porcelain-fused-to-metal crown.



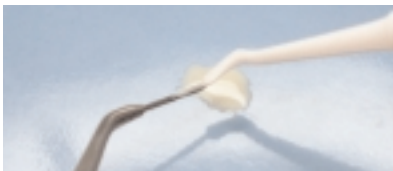
**Fig. 2** Cutting of the post using a diamond disk.



**Fig. 3** Microetching of the post with 50-µm aluminium oxide.



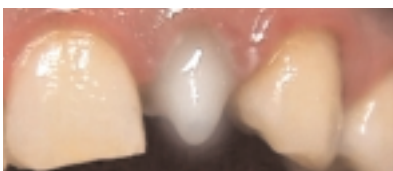
**Fig. 4** ED-Primer was applied on the post surface.



**Fig. 5** Composite cement application on the primed post.



**Fig. 6** Cementing of the post into the canal.



**Fig. 7** Clean finish of the post-and-core system.



**Fig. 8** The stronger and aesthetic metal-free restoration.

## INTRODUCTION

Posts and cores in endodontically treated teeth have been utilized for more than a century as a means to retain the foundation of the final restoration. It has been shown, however, that they can weaken the tooth. Failures of traditional metal post restorations are caused mainly by root canal fracture due to the very different modulus of elasticity of the tooth structure and metal post. Custom cast metal posts and cores used to retain restorations remain indicated only in endodontically treated teeth with small clinical crowns. Besides metal posts are not indicated for people with metal allergies (9). The range of indications for a cast metal post-and-core system as an indirect prosthodontic procedure has recently become smaller, indeed. Nowadays, metal-free posts have been introduced for post-and-core endodontic restorations. Their dramatically different physical properties allow them to dissipate compressive, tensile and shear stress, rather than transferring and concentrating excessive loading in the residual root structures as with metal posts. One of the modern metal-free posts is the carbon fibre composite post. It offers greater strength for the final restoration, since its elasticity is close to that of dentin. In other words, working with this post the dentist can create a more integrated complex of the root canal, the post and the core. The properties of this post contribute greatly for the uniform distribution of the loading forces on the root structure. This makes the carbon post very suitable for reinforcement of compromised roots and root fracture prevention. Endodontic treatment is commonly used in dental caries leading to destruction of tooth structure and pulpitis, secondary caries reducing tooth tissue, tooth crown fracture due to large obturation, in external injuries, non-caries defects (enamel and dentin malformations), previous tooth devitalization with extensive structure removal, iatrogenic causes compromising the tooth structure, etc. (7). The present paper illustrates a technique for rehabilitation of an endodontically compromised tooth with a carbon fibre composite post.

## MATERIAL AND METHODS

The study covered a 35-year old male patient with fractured maxillary left lateral incisor (Fig. 1). The tooth had been restored with a porcelain-fused-to-metal crown following endodontic therapy about two years ago. In order to ensure sufficient tooth resistance against root fracture, Carbonite, a carbon fibre composite post (H. Nordin sa, Brent/Montreux, Switzerland) was used. In order to meet the patients' aesthetic requirements a

metal-free crown Estenia hybrid ceramics, (Kuraray Co., Ltd., Osaka, Japan) was placed. Both the post and the crown were adhesively cemented with Panavia F (Kuraray Co., Ltd., Osaka, Japan). It is a new dual-cure resin cement that is fluoride releasing, antibacterial, self-adhering and self-etching product.

## PROCEDURE DESCRIPTION

The complex method used with this patient included the following main stages; i) diagnosis by computerized dental radiography; ii) root canal preparation and post cementation; iii) core build-up, and iv) crown fabrication and placement. A computer-aided radiographic image (CDR, Schick Technologies, USA) was used to test the quality of filling, the periapical space and root canal dimensions. Angulation of x-ray beam in relation to the tooth was an important prerequisite for proper diagnosis (3). CDR technology enabled much more precise determination of the sizes than a conventional x-ray film. Two-thirds of the total canal length were defined for the post hole. The post size was selected according to the measured diameter of the canal. The depth (length) were transferred on a calibrated reamer. The flared canal was prepared to the required size and depth using this reamer on a slow-speed handpiece. A Carbonite post was tried into the prepared root canal. Then it was cut to the necessary length using a diamond disk (Fig. 2). Pliers should not be used to cut the post as the pressure could destroy its structure. It was microetched with 50-µm aluminium oxide (Danville Engineering, San Ramon, CA, USA) for 3 - 4 sec. (Fig. 3). After sandblasting, the post was washed in a stream of water. Then it was ultrasonically cleaned for two minutes in a neutral detergent solution to remove any debris. Finally, the post was placed in a protective container. The working field was isolated. The canal was rinsed thoroughly and lightly dried to remove the majority of the water. Excess water was blotted dry with endodontic paper points. The root canal space was cleaned using Tubulicid Plus (Dental Therapeuticus, Nacka, Sweden) to remove any remnants of eugenol and debris. If eugenol containing temporary materials were used, pumice should be applied to thoroughly remove all traces of it. In such a case, the patient should be invited for another visit after several days. According to the instructions of the producer it is not necessary to acid-etch the root canal walls and the residual tooth surface when cementing with Panavia F since the ED Primer (Kuraray, Osaka, Japan) combines etching, priming, bonding and disinfecting

into a single step. ED-Primer was prepared by dispensing and mixing equal amounts of liquid A and liquid B for 5 sec. The mixture was placed into the canal using a Microbrush (Microbrush, Inc., Grafton, USA) applicator to completely saturate the canal walls. After 1 min during which the mixture penetrated into the collagen fibres, the canal was carefully dried with paper points. The volatiles were evaporated with a gentle stream of air and the surface appeared glossy. A part of the same mixture was applied on the surface of the cleaned and dried post for 30 sec (Fig. 4) and lightly dried to achieve gloss. Equal parts of Base and Catalyst of dual-cure resin cement were mixed. Because of Panavia F anaerobic properties the mixture should be spread in a thin layer on the pad until ready to use. A thick, uniform layer of the composite cement was applied to the primed post carefully to avoid air entrapment (Fig. 5). Because of the possibility the set of Panavia F paste to be accelerated as a result of its reaction with the ED Primer in the canal, additional application of the cement was not realized. The post was carefully seated into the canal using light pressure (Fig. 6). The cement which had been expressed from the canal during post seating was used as a base for the build-up. The cement light-cured in place for 20 sec. Additional amount of the cement was spread in a thin layer over the post and coronal tooth structures and light-cured in place for 20 sec. For the building-up of the core was used self-cure composite Clearfil Core (Kuraray Co., Ltd., Osaka, Japan) with high resistance to compressive loading and which could completely mask the dark color of the post. Equal amounts of Base and Catalyst self-cure composite were mixed. The composite was applied over the post and the coronal structure. The tooth restored with the post-and-core system was minimally prepared to ensure a clean finish of the margins of the structure for the planned metal-free crown (Fig. 7). The design of the preparation chosen was a butt joint margin. The colour of the definitive restoration had already been selected. An impression was taken with a triple tray allowing for a dual arch impression with no cord and sent to the laboratory for fabrication. Estenia Hybrid Ceramic (Kuraray, Osaka, Japan) was preferred for the crown. After receiving the restoration it was tested for marginal fit. The occlusion was checked and adjusted. The lab work was excellent in form and function. Adhesive cementation of the crown was performed with Panavia F dual-cure adhesive system. The result was a fracture resistant, stronger and more aesthetic metal-free restoration in comparison with the traditional restorations retained by metal post and core systems (Fig. 8).

## DISCUSSION

Our clinical observation reveals a series of advantages of the metal-free endodontic rehabilitation. This technique is easy to perform and safe for both patient and dentist. While the metal post may cause early root fracture due to the excessive tooth structure removal and direct transmission of masticatory loading forces from the post onto the tooth root, the metal-free post possesses a modulus of elasticity identical to that of dentin and thus increases the strength of the remaining tooth structure (7). Therefore, this new technique results in strong restorations with natural translucency. The metal-free post is highly biocompatible and not subject to corrosion and discolouration.

The question of whether a post placed in an endodontically treated tooth actually increases its strength is still being debated (6). The metal-free endodontic treatment promises to be the method of choice in cases of destroyed tooth structure as it enables the achievement of longevity and aesthetics of the restorations (8). With the growing patients' awareness of the possible cosmetic treatment alternatives comes the desire for more aesthetic, metal-free, durable restorations. Usage of carbon fiber-reinforced epoxy resin posts showed promising results after 2 to 3 years of clinical service suggesting that this system can be a viable alternative to conventional post-and-core systems (4). Crowned, root-filled teeth with a high quality endodontic treatment and an optimal morphology of the dowel and core have a similar survival rate as crowned teeth with a vital pulp, i. e., over 25 years of observation (13). In a series of in-vitro studies (2, 11, 12) the physical properties of the new post systems are comparatively elucidated.

With recent advances in adhesive techniques, restorative materials have evolved to an enhanced level of aesthetics enabling more conservative cavity preparations and reinforcement of the remaining tooth structure. The luting composite cement connecting the metal-free post and dentin warrants a stable and homogenous structure. The durability of thus created new structure is remarkable. Post selection is dependent on individual patient needs and dentists' preference. Ceramic posts are strongest, and their cost is highest. Metal posts perform the best all around when comparing strength, but they cause tooth fracture under load more often than the metal-free posts. Carbon based posts' strength perform adequately and are a cost effective alternative to metal posts (1,9). There are recent studies illustrating the better physical properties of carbon fiber root canal posts over the stainless steel ones (10).

We could conclude that Carbonite, the carbon fibre composite post, can be easily

used by contemporary aesthetic dentists. This technique provides the benefits of root strengthening and natural aesthetics when endodontically restoring the compromised tooth. It successfully combines the adhesive cementation with the metal-free core build-up procedure.

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Extract from

# Flexural properties of fiber reinforced root canal posts

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## Introduction:

Crown restoration of an endodontically treated tooth often requires additional support from the root canal by means of a root canal preparation and the fabrication of a post and core restoration. Recent reports suggest that the rigidity of the post should be equal or close to that of the root of the tooth to distribute the occlusal forces evenly along the length of the root.

Prefabricated and cast metal posts are traditionally used. They are, as well as the novel all-ceramic posts, rigid in nature. The rigidity may pose a risk for root fracture. Recently, fiber reinforced composite (FRC) root canal posts have been introduced as an alternative to more conventional materials. The biomechanical properties of FRC posts have been reported to be close to those of dentin. Teeth restored with e.g. carbon/graphite fiber posts are found to resist fracture propagation better than teeth restored with prefabricated titanium posts or cast metal posts. Ongoing clinical trials are also suggesting good results. No post-associated failures during 3 year of follow-up were reported in a study where 236 endodontically treated teeth were restored using carbon/graphite fiber posts. The failure rate using prefabricated metal posts was reported to be 8%.

FRC posts contain a high volume percentage of continuous reinforcing fibers embedded in a polymer matrix, which keeps the fibers together. Matrix polymers are commonly epoxy polymers with high degree of conversion and a highly cross-linked structure. The first FRC-posts were made of carbon/graphite fibers due to their good mechanical properties. However, they are black in colour and thus lack cosmetic qualities. Instead posts made of glass or silica fibers are white or translucent and can be used in situations of higher cosmetic demand.

Many studies concerning the mechanical properties of FRC root canal posts have been done. Although the flexural strength of FRC posts have been shown to be relatively high, large variations in the reported flexural modulus of carbon/graphite fiber posts can be found. The flexural properties are found to decrease after moisture adsorption.

Glass fibers have a lower elastic modulus than carbon/graphite fibers. Glass fiber posts can be made of different types of glasses. Electrical glass (E-glass) is the most commonly used glass type in which the amorphous phase is a mixture of SiO<sub>2</sub>, CaO<sub>2</sub>, B<sub>2</sub>O<sub>3</sub>, Al<sub>2</sub>O<sub>3</sub> and some other oxides of alkali metals. S-glass (high-strength glass) is also amorphous but differs in composition. Additionally, glass fiber posts can also be made of quartz-fibers. Quartz is pure silica in crystallized form. It is an inert material with a low coefficient of thermal expansion (CTE).

The stability of fiber/polymer matrix interface and the effect of possible mismatch of CTEs between fibers and matrix polymers must be considered when the clinical longevity of FRC posts is evaluated. To our knowledge, there remains a lack of studies concerning the stability of FRC posts after thermal cycling. The aim of this study was to investigate the flexural properties and fracture load values of different types of FRC posts and compare those values with a novel high strength FRC material for dental

applications. Furthermore, the influence of thermal cycling in water on the flexural properties was determined.

## Materials and methods:

Seventeen different FRC posts of various brands and diameters, and continuous unidirectional glass fiber composite shaped into the form of a post, were tested. Five posts of each type were tested as dry (stored in room humidity) and five were tested after thermocycling in water (12.000 x, 5°C/55°C, dwelling time of 30 s). Subsequent to thermocycling the posts were stored in water for 2 weeks before mechanical testing.

The three-point bending test according to the ISO 10477 standard (span 10.0mm, crosshead speed 1.0mm/min, cross-sectional diameter of loading tip 2 mm) was used to measure the flexural strength and modulus of FRC post specimens. All posts were tested with a material testing machine (model LRX, Lloyd Instruments, Fareham, England).

Fracture load of post was measured. Flexural strength ( $f$ ) and flexural modulus ( $E_f$ ) were calculated from the formula:

$$f = 8F_{\max} / d^3$$

$$E_f = S4l^3 / (3 d^4)$$

Where  $F_{\max}$  is the applied load (N) at the highest point of load-deflection curve,  $l$  is the span length (10.0mm),  $d$  is the diameter of the specimens.  $S=F/D$ , the stiffness (N/m) and  $D$  is the deflection corresponding to load  $F$  at a point in the straight line portion of the trace. In order to eliminate the influence of the conical end of some of the posts, a short span length was used to get support for the post within the cylindrical part of the post. The parallel-sided cylindrical part of the post was considered to be the specimen. The specimens were polymerized in a light curing oven (LicuLite, Dentsply De Trey GmbH, Dreieich, Germany) for 40 min.

In addition 2 posts of each group were embedded in PMMA and wet-ground with 40 (FEPA). After that, specimens were sputtered (SCD 050, BAL-TEC AG, Balzers, Liechtenstein) with gold and transverse sections of posts were visually examined with a SEM (JSM-5500, JEOL Ltd, Tokyo, Japan) to determine the differences in posts.

Flexural properties were analysed with three way ANOVA (SPSS, SPSS Inc., Ill, USA) to evaluate the effect of thermocycling, brand of material and diameter of specimen. To determine statistically significant differences the tukey post hoc test was used.

## Results:

The flexural strength, flexural modulus and maximum fracture load of tested specimens are presented in Figs 1-2. The analysis of ANOVA revealed that thermocycling, brand of material and diameter of specimen had a significant effect ( $P < 0.001$ ) on the fracture load and flexural strength. In general, thermocycling decreased the flexural modulus of the tested specimens by approximately 10% (Fig. 2). Strength and fracture load decreased

by approximately 18% as a result of thermocycling. The average reduction percentage in fracture load after thermocycling of the tested post specimen is presented in Fig. 4. visual analysis of SEM-micrographs revealed that a certain amount of porosity in competitor A was easily recognized whereas Glassix® had a tight solid matrix without porosity.

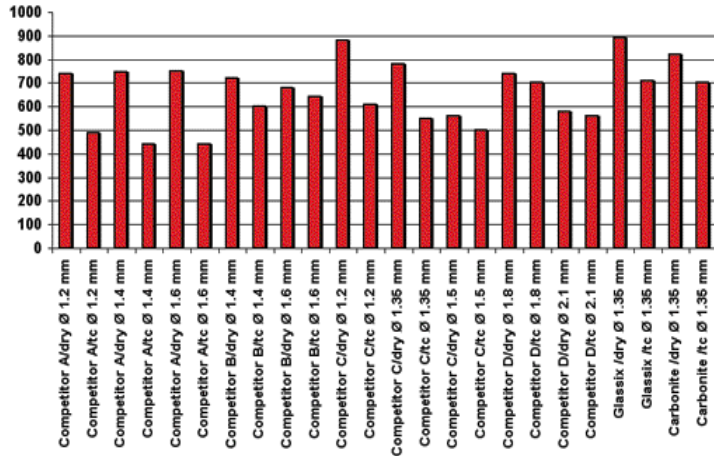


Fig. 1: Flexural strength of FRC posts (Mpa)

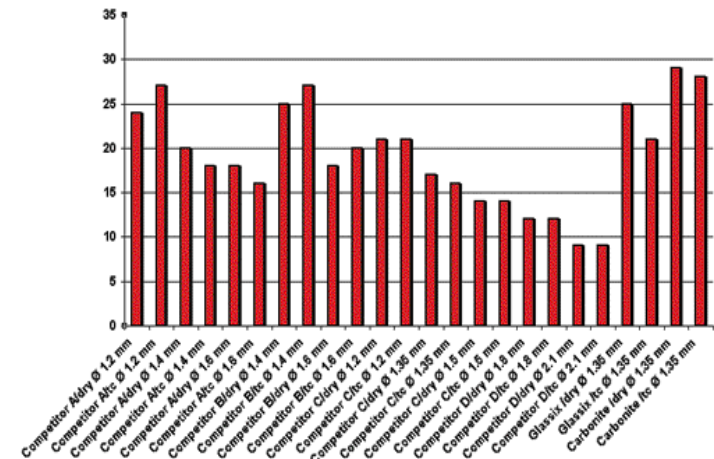


Fig. 2: Flexural modulus of FRC posts (Gpa)

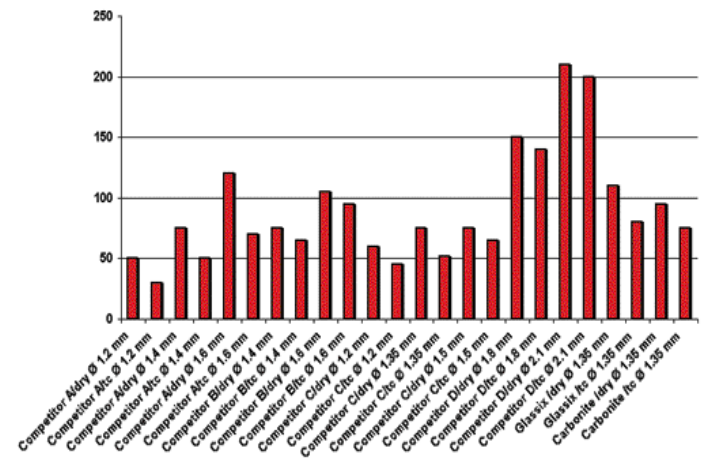


Fig. 3: Maximum fracture load of FRC posts (N)

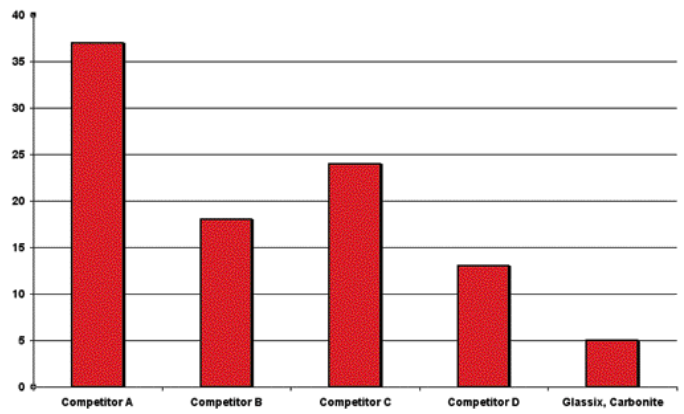


Fig. 4: Reduction of fracture load of dry and thermocycled specimens

**Discussion:**

Many studies concerning the mechanical properties of FRC posts have recently been published. Lack of standardization of the testing conditions and methods has resulted in large variations in the mechanical properties reported. In the present study, thick posts showed lower flexural strength values (MPa) than thin posts although the fracture load values (N) behaved oppositely. The results show that when a three-point bending test is used to measure flexural properties of FRC-posts, the results are related to the ratio of span length and diameter of the test set-up.

As seen in this study all FRC post specimens showed a linearly increasing resistance against loading force along with an increase in diameter. Both carbon/graphite and glass fibre reinforced posts behaved similarly. However, if interfacial bonding between fiber and matrix is not adequate, no better mechanical properties are acquired.

Differences in the mechanical stability after thermocycling were found between the post specimens tested. Competitor A specimens showed approximately 40% in flexural strength after thermocycling, whereas flexural strength of the other post brands tested and the Glasix®, Carbonite® posts decreased by approximately 5% as a result of thermocycling. On the other hand, a study by Torbjörner et al. reported a 65% decrease in the mechanical properties of the Competitor D carbon /graphite fiber posts after thermocycling. However they compared posts with different diameters with each other and the results are thus affected by the influence of the L/D ratio.

When specimens are exposed to thermocycling the differences between coefficients of thermal expansion (CTE) of the individual material may affect the long term stability of the FRC-post-tooth combination. Large variations in CTE exist between reinforcing fibers and the matrix polymer used in FRC posts (polymer matrix: 40-80x10<sup>-6</sup>/°C, E-glass: 8x10<sup>-6</sup>/°C, quartz: 0.2x10<sup>-6</sup>/°C, carbon-/graphite-fiber: 0.4x10<sup>-6</sup>/°C). It should be emphasized that the thermomechanical behaviour of anisotropic/orthopaedic/isotropic dental FRCs is not fully understood at the moment. The reduction in flexural properties of Competitor A specimens after thermocycling could be related to the discrepancy in the CTE between the materials of Competitor A composite. The difference in CTE between silicazirconium fibers and the polymer matrix is bigger than that of E-glass, S-glass and carbon/graphite fibers and matrix polymer. Also the porosity, which is seen in

the SEM-micrographs of Competitor A might be one explanation for the reduction of mechanical properties after thermocycling.

The present study has to be considered as a short-term water exposure study. Our results are in accordance with several other studies showing that a decrease in mechanical properties is taking place during 30 days of water storage and is caused by plasticization of the polymer by water. In long-term water exposures, hydrolyzation of the silane coupling agent which is used to promote adhesion between the fibers and the polymer matrix, might play a major role.

Interestingly, it was found that the Glassix® glass fibre composite post and the Carbonite® carbon fibre composite post have the lowest reduction of fracture load of dry and thermocycled

specimens. This unexpected finding could be explained by the optimization of the polymer matrix and fiber properties to function as a composite material.

Clinically, it is well established that the longevity of root-post-core-crown systems used to restore an endodontically treated tooth is affected by many factors e.g. the design, length and thickness of the post, the ferrule effect, cementation and the quantity of remaining tooth substance. Many in vitro studies have shown that FRC posts due to their modulus of elasticity being closer to that of dentin. This phenomenon of modulus compensation of stress induced root fractures could have an impact on the post-core-crown restorations in the future.



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