Fiberglass reinforced composite endodontic posts

Jürgen Manhart presents a clinical case using fiberglass reinforced composite endodontic posts

The prosthetic treatment of seriously damaged, endodontically-treated teeth often require an endodontic post as an additional retention element for core build-up prior to crown restoration. In addition to metal-based posts and zirconia-based ceramic posts, fiber-reinforced composite posts have recently become a center of interest for dentists and science.

In the past it was commonly accepted that teeth would become brittle after root canal treatment, and manifest as an increased risk of fracture. Allegedly, the strengthening effect of endodontic posts should compensate for the weakness. We now know that the mechanical properties of tooth substance are not significantly impaired by endodontic treatment (Kurtz et al, 1981; Reeh, Messer, Douglas, 1989).

Weakening of endodontically-treated teeth is rather the result of additional carious or traumatic destruction, pre-existing loss of tooth substance through the access cavity and the preparation of the root canals (Linn, Messer, 1994; Reeh, Messer, Douglas, 1989). Further tooth substance removing measures – such as unnecessary, expansive preparation of the canals and post preparation for endodontic posts – additionally weaken the tooth. The strength of endodontically-treated teeth cannot be increased through endodontic posts. On the contrary, weakening and/or an increase in clinical failure in teeth with endodontic posts is a possibility.

Indications for endodontic posts

Reliable retention for the definitive restoration while preserving the maximum amount of healthy tooth substance possible should be the aim during the coronal build-up of endodontically-treated teeth (Nergiz et al, 2004). Today, the use of endodontic posts can be avoided in many cases with the help of the adhesive technique. In cases with an insufficient amount of coronal tooth substance, a composite build-up for endodontic posts with only adhesive anchoring offers the possibility of creating additional retention for the build-up. The answer to the question of whether an endodontic post is necessary, thus, depends on the degree of destruction of the clinical crown:

- Teeth with a minimal amount of destruction can be prepared using adhesive-anchored direct composite build-up for the prosthetic restoration
- With a medium amount of destruction, a build-up with post anchoring can likewise be avoided thanks to the adhesive technique
- With an extensive amount of destruction of the clinical crown, an endodontic post should be used to create reliable anchoring of the build-up.

More exact information on this topic, as well as the answer to the question of when is the correct time to prepare the final restoration, can be taken from the shared scientific opinion of the DGZMK (German Academic Association of Dentistry), DGZPW (German Association of Prosthodontics and Dental Materials) and the DGZ (German Association of Dentists) in ‘Aufbau endodontisch behandelter Zähne’ (2003) (English translation: Build-up of endodontically-treated teeth).

Requirements of endodontic posts

The fundamental requirements of endodontic posts include, high tensile strength, high fatigue resistance to occlusal and shear loading and stress-free distribution of the forces affecting the tooth root. Excellent fitting accuracy, biocompatibility and innocuous electro-chemical activity are also essential. Unnecessarily weakening the tooth root through increased substance loss should be avoided by selecting a suitable post form (Edelhoff, Spiekermann, 2003).

For therapy of esthetically-challenging situations these days, full-ceramic crowns and bridges fabricated from translucent ceramic are widely used, especially in the anterior and premolar regions. These are comparable to natural teeth with respect to their light conducting properties. The expectations of the optical properties of endodontic posts are rising in response to the demand for esthetic restorations in teeth that have undergone root canal therapy. Unesthetic effects, originating from the endodontic post shining through...
and metal or black carbon fiber posts construction, cannot be reconciled with high expectations of esthetic results (Nergiz et al, 2004).

In addition to metal pins, which can be subdivided into active pins with screw thread and passive designs, up-to-date metal-free systems made from high-strength zirconium oxide ceramic and fiber-reinforced composites are available (Edelhoff, Spiekermann, 2003). In addition to the unfavorable optical properties, the disadvantages of metal posts include high rigidity (high E modulus) with resulting concomitant risk of hypercritical stress peaks (with active posts foremost from the thread outward) and the problem of corrosion. Full ceramic posts made from zirconium oxide are indeed almost tooth-colored. They represent, however, an increased risk in the occurrence of tension peaks. This is due to extremely hard and inelastic materials (E modulus ca. 200GPa) that are not in harmony; from a biomechanical viewpoint, with the relatively elastic dentin (E modulus ca. 18-20GPa) of the tooth root. A consequential increased risk of root fractures is possible. In most cases involving complications, the zirconium oxide posts cannot be removed without considerable and irreparable damage to the tooth root due to their considerable hardness.

**Fiber-reinforced composite endodontic posts**

Fiber-reinforced composite posts consist of a resin matrix, in which structural reinforcing carbon fibers or quartz/glass fibers are embedded. Black carbon fiber-reinforced composite posts are, on the one hand, poorly suited for combination with translucent full ceramic restorations due to their unfavorable optical properties. On the other hand, carbon fiber posts also have unfavorable biomechanical properties (significantly higher E modulus, ca. 120GPa) in comparison to the nearly tooth-colored quartz fiber and glass fiber posts.

The quality of fiber-reinforced composite posts, which are now offered by a large number of manufacturers, varies greatly. The manufacturing process determines the quality. The highest quality provides the most even distribution of the fiber in the organic matrix possible with the packing of the fibers as dense as possible, a good combination of fibers with the matrix, a high degree of polymerization of the organic components and a homogeneous post structure without blisters and inclusions (Grandini et al, 2004). After polymerization, the blanks are brought into their final form through a milling process. There are different post geometries, which also exhibit considerable differences in surface quality due to variations in the milling.

Endodontic posts fabricated from quartz fiber- or glass fiber-reinforced composite have favorable biomechanical properties. They feature high tensile strength and, at the same time, exhibit elasticity characteristics that are similar to dentin (Pfeiffer, Nergiz, Platzer, 2002). This minimizes the risk of root fractures, caused by tension peaks induced by loading and shear forces, through the most stress-free distribution possible of these arising forces in the tooth root. The even load distribution is supported through the friction-locked bond between post and tooth substance, due to the adhesive luting of the fiber post in the root canal with composite cement. The adhesive bond, however, appears to be inferior to the radicular dentin due to the structural differences in comparison to coronal dentin sections (Kurtz et al, 2003; Mjör et al, 2001).

The favorable optical properties of tooth-colored fiber posts (glass- and quartz-fiber), which are consistent with natural teeth in their ability to conduct light, facilitate the goal of esthetic, high-quality restorations when they are combined with full ceramic materials. The posts can be processed in one time-saving surgery visit that eliminates the laboratory step, due to the direct technique in combination with an adhesive composite build-up. They also permit a procedure that is gentle to the tooth substance: Thin dentin walls are stabilized by the plastic build-up composite and the composite cement. Moreover, the areas underneath can be saved and maintained as additional retentive areas for the plastic build-up composite restoration (Monticelli, Goracci, Ferrari, 2004).

The rare failures of fiber posts are either due to loss of adhesion or caused by a fracture of the post. Catastrophic collapse, which leads to a fracture in the tooth root, is less likely in contrast to posts made from metal or zirconium oxide (Mannocci, Ferrari, Watson, 1999). Contrary to tooth-colored posts made from zirconium oxide, posts made from fiber-reinforced composite can be removed from the root canal, if the need arises, without serious problems caused by excavation with a rotating instrument.

**Clinical case**

The following clinical case represents the clinical steps involved in the utilization of a fiber-reinforced composite endodontic post in a maxillary central incisor and the subsequent treatment with a full ceramic crown.

A 38-year-old patient presented in our surgery with the desire to replace an unsightly crown on tooth 11 and have a veneer placed on tooth 21 (Figure 1). The porcelain-fused-to-metal crown on the right central incisor was too short and the tooth core was extremely discolored. The tooth reacted unremarkably to percussion and did not display any response to a cold sensitivity test. An endodontically-treated tooth with a metal post in the root and a normal periapical region was identified in the X-ray (Figure 2). Other than a large, mesial, provisional composite build-up, tooth 21 was clinically and radiologically...
unremarkable. After presenting and explaining the therapy alternatives, a decision was reached to remove the crown on tooth 11 and attempt to take out the metal post. Subsequent insertion of an adhesively anchored, fiber-reinforced, composite endodontic post and fabrication of a zirconium oxide ceramic crown were planned. A ceramic veneer for tooth 21 was also arranged.

After the crown was removed from tooth 11, the build-up material was carefully removed and the coronal portion of the metal endodontic post displayed (Figure 3). The post exhibited good retention, so an attempt was made to destroy the integrity of the cement with ultrasonic energy (Figure 4) in order to remove the post without endangering the root and longitudinal fracture. After a short time, the post loosened and could be easily removed from the canal (Figure 5). After displacement of the metal post through the enlarged root canal access, the length of the existing depth drill was determined with an endodontic instrument in order to subsequently follow this path again. This would be carried out from a coronal reference point moving outward with a precision drill from the selected post system.

A glass fiber-reinforced composite post that could be adhesively luted (Rebilda Post, Voco) was chosen as the post system. After placing a retraction cord and selecting the appropriate post diameter, the excavation of the post hole by drilling in the root canal was carried out with a depth-marked precision drill (Figure 6). The penetration depth was already preset by the old metal post in this case. The length of the post drilling should generally be chosen so that at least 4mm of root filling remains, in order to tightly seal the apical section of the apex.

Figure 7 shows the try-in of the Rebilda Post (Voco) with the coronal maximum possible diameter (2.0mm) available. The fiber-reinforced post was inserted into the cavity and parietal fit verified. Rebilda Post glass fiber-reinforced composite posts are available in three sizes (coronal diameter: 1.2mm, 1.5mm and 2.0mm) and have a cylindrical-conical design. The tapered anatomical shape of the tooth root is taken into account in the apical region with the conical shape of the post. This permits a preparation that is gentle to the tooth substance, compared to the preparation required for straight, parallel-walled post systems.
Cleaning the post with alcohol, drying it with air and subsequent silanisation (Ceramic Bond, Voco) are carried out by the dental assistant as preparation for the luting. The task of disinfecting the post preparation is carried out concurrently according to the manufacturer’s instructions; cleanse with 3% NaOCl (Figure 8), flush with water (Figure 9) and dry with paper points (Figure 10).

A matrix system was mounted on the tooth to secure the shape of the build-up. Futurabond DC (Voco), the self-etching, dual-curing adhesive, was rubbed into the remaining tooth substance in the post hole for 20 seconds with a small endomicrobrush (Figure 11) and then the solvent evaporated with oil-free air. Excess adhesive was removed from the post hole with the assistance of a paper point (Figure 12). Rebilda DC in the QuickMix syringe (Voco), a dual-curing, low viscosity, core buildup composite, was applied in the post hole with a slender application tip immediately afterwards. The tip of the cannula was inserted to the deepest point in the post preparation in the tooth and the Rebilda DC was continuously applied while slowly withdrawing the tip from within the tooth. Careful attention to the process ensured that the opening of the intra-oral tip was always immersed in the luting composite. This type of ‘immersion filling’ ensures that there are no air bubbles in the cement layer, which also results in maximum adhesion to the canal wall and increased integrity.

The excess cement that escapes from the coronal opening of the post drilling is equally utilized as part of the build-up filling. The coronal composite build-up with Rebilda DC is created in the same workstep with the same application cannula after the post is inserted (Figure 13). The composite was subsequently polymerized for 40 seconds (Figure 14) with a polymerization light. After removing the matrix, tooth 11 was immediately prepared for the accommodation of a zirconium oxide ceramic crown (Figure 15). A prepared dentinal edge is clearly discernable beneath the composite build-up. The dentin border, which is a minimum of 2mm wide on all sides in the ideal case, will be circularly surrounded by the definitive crown. This so-called ferrule effect stabilizes the tooth root treated with an endodontic post and increases the verifiable solidity of the restored system. The left, central incisor was prepared for a ceramic veneer (Figure 15). A
temporary was fabricated from the impressions that were taken (Figure 16). The adhesively cemented fiber-reinforced composite post is clearly discernible on the verification X-ray (Figure 17). Figure 18 shows the completed, restored teeth with an integrated zirconium oxide crown on tooth 11 and adhesively luted ceramic veneer on tooth 21.

Summary
Endodontic posts do not increase the stability of the remaining tooth substance in endodontically-treated teeth. On the contrary, they weaken them as a result of the additional substance loss due to the post hole drilling. In many cases with a high degree of damage to the clinical crown, the additional loss of this tooth substance is necessary for the long-term retention of the build-up. A system should thus be chosen that minimizes the risk of root fracture, based on biomimetic properties. Adhesively luted endodontic posts reinforced with glass- or quartz-fiber lead to better homogeneous tension distribution when loaded than metal or zirconium oxide ceramic posts and contemporaneously possess advantageous optical properties. To date, however, there are only relatively few clinical studies on metal-free post systems that are promising. There are admittedly substantial differences in the mechanical loading capacity of the different fiber-reinforced endodontic posts.

The practitioner should be aware of such differences in order to select a suitable post system followed by a thorough investigation.

References