The restoration of root-filled posterior teeth

Philip Newsome, David Reaney and Siobhan Owen explore current thinking regarding the restoration of root-filled posterior teeth.

All dentists are aware of the fact that root-filled teeth behave differently to vital teeth and are, in general, more prone to fracture. There is still, however, some confusion as to the best way to restore such teeth. The goal of this article is to explore current thinking regarding the restoration of root-filled posterior teeth.

Why do root-filled teeth fracture?

For many years the increased risk of fracture exhibited by non-vital/root-filled teeth was thought to be a result of desiccation or premature loss of fluids supplied by vital pulps. This assumption appeared to be confirmed by the work of Heller et al (1972) who reported that there was approximately 10% less collagen-bound water in non-vital teeth and that such ‘drying out’ led to a deterioration in the tooth’s physical properties. It has also been suggested that root-filled teeth undergo changes in collagen cross-linking (Riera EM, Yamauchi M, 1993). While these theories do carry some credence, increasingly it is believed that the ability of a root-treated tooth to resist fracture is directly related to the amount of remaining tooth structure (Vale WA, 1956; Larson TD et al, 1981; Mondelli J et al, 1980).

Prior to Heller’s findings, Fusayama and Maeda (1969) had shown that there is no difference in the modulus of elasticity, hardness or fracture resistance of pulpless teeth. In other words, as more tooth structure is removed, the resistance to occlusal forces is diminished and the likelihood of fracture increases – more on this later when we discuss the choice of final restoration.

Modern endodontic practice prefers an access cavity preparation for parallel posts, as more dentine is removed from the root canal, more dentine removal is required in their post space preparation. This can be undesirable, especially in post space preparation for parallel posts, and posts are therefore required more often in premolars. The placing of posts in premolars does present its own particular difficulties, however. In addition to root taper and curvature, many premolar roots are thin mesiodistally, and some have proximal root invaginations. Furthermore, the clinical crown of the mandibular first premolar is often inclined lingually in relation to its root. These anatomical characteristics must be considered carefully during post space preparation to avoid perforating the root.

If a post is deemed necessary, which type should be used? A photo-elastic stress analysis of post design (Rolff KC et al, 1992) led to the conclusion that cement-retained posts were the least stressful to the tooth, followed by cast root, then metal and, and posts are therefore required more often in premolars. The placing of posts in premolars does present its own particular difficulties, however. In addition to root taper and curvature, many premolar roots are thin mesiodistally, and some have proximal root invaginations. Furthermore, the clinical crown of the mandibular first premolar is often inclined lingually in relation to its root. These anatomical characteristics must be considered carefully during post space preparation to avoid perforating the root.

Material choice for posts

Stainless steel, titanium and titanium alloys, gold-plated brass, ceramic and fibre-reinforced polymers have all been used as materials for prefabricated posts. The ideal material should possess physical properties – such as modulus of elasticity, compressive strength and coefficient of thermal expansion – similar to those of dentine. In addition, posts should not be corrosive and should bond easily and strongly to dentine inside the root using suitable cement so that the entire assembly of a post and core resembles the original tooth. Unfortunately, no such material is available to date even though fibre-reinforced posts look promising.

The advantage of fibre-reinforced posts is that, paradoxically, the physical strength of these posts is significantly weaker than that of metal posts (Sirona S et al, 1999; Newman MP et al, 2003). Highly rigid metal posts transfer lateral forces without distortion to the less rigid dentine and therefore lead to a greater possibility of root fracture. The lower flexural modulus of fibre-reinforced posts, on the other hand, is closer to that of dentine, thus, in theory, decreasing the incidence of root fracture (Martinez-Insua A et al, 1998). In addition, should failure occur, teeth are more likely to be restorable when fibre-reinforced posts have been used (Cormier CJ et al, 2001; Akkayan B, Gulmez T, 2002).

Fibre-reinforced posts are designed to bond with most resin cements and resin-based composite core materials. Successful bonding minimises the wedging effect of the post within the root canal, requires less dentine removal to accommodate a shorter and thinner post, and leads to lower susceptibility to tooth fracture. Successful bonding also means that the shape (parallel versus tapered) of the fibre-reinforced post may be less significant in relation to its retention than for a metal post. Finally, fibre-reinforced posts can be removed easily in case of endodontic failure requiring retreatment. A number of studies (Ferrari M, Mannocci F, 2000; Fredrickson M et al, 1996) that evaluated a variety of fibre-reinforced posts over a period of six years reported failure rates of between 3% and 5%, concluding that these posts can be used routinely in combination with bonding materials.

Ceramic posts have also been introduced into the marketplace in recent times. These exhibit excellent biocompatibility, high flexural strength and fracture toughness (Ichikawa Y et al, 1992) and are aesthetically pleasing, especially under all-ceramic crowns. However, two in vitro studies (Dietzsch D et al, 1997; Hedlund SO et al, 2003) reported poor resin-bonding capability of ceramic posts to dentine under fatigue testing and, clearly, further development and clinical research is likely to take place.

Intracoronal or extracoronal final restoration?

The final restoration plays a critical role in determining the ultimate strength of a root-filled tooth (Gelfand M et al, 1984). One of the most informative studies in this area is that of Reeh (1989), who compared the contributions of endodontic and restorative procedures to the loss of cuspal stiffness by using non-destructive occlusal loading on extracted intact human teeth. The study found that an occlusal cavity preparation caused a 20% reduction of cuspal stiffness while endodontic procedures reduced the relative stiffness by only a further 5%. Mesial-occlusal-distal (MOD) cavity preparation caused a whopping 63% reduction. The conclusion was reached that
endodontic procedures do not significantly weaken teeth provided that the marginal ridges remain intact and that the greatest factor influencing the strength of endodontically treated teeth (specifically premaxillary) is the amount of remaining tooth structure. If a tooth is not fractured or severely damaged by caries before endodontic treatment, it may therefore be sufficient to treat the endodontic access by means of a simple restoration. It is, of course, more than prudent to look out for cracks within the tooth tissue, especially those appearing in the floor of the pulp chamber, as well as excessive or unusual occlusal loading (as found in parafunctional activity), which may increase the likelihood of tooth fracture.

In these situations, resin-based composite with acid etching of enamel and dentine is increasingly the restoration of choice and has been shown to improve the fracture resistance of root-filled teeth (Hernandez R et al, 1994; Mannocci F et al, 2002).

Recently, Belli (2006) demonstrated in vitro that the incorporation of woven polyethylene fibre (Ribbond) in a buccal-to-lingual direction over (MOD) composite restorations in the buccal-lingual direction over (MOD) composite restorations has been shown to improve the fracture resistance of root-filled teeth. This approach places far less stress on the underlying tooth and, as long as the final crown margin extends at least 2mm beyond the core margin, the resulting ferrule effect ensures a strong, long-lasting final restoration.

Core is not without its difficulties. Amalgam requires a prolonged setting time, making it difficult to prepare immediately after placement if a crown is the final restoration. Placing amalgam can be challenging in badly broken-down teeth, and many patients are concerned about the presence of mercury in amalgam, regardless of whether there is scientific evidence as to toxicity.

The advantages of using composite as a core material (Figure 5) are that it can bond to tooth structure and therefore, theoretically, strengthen the tooth/restoration unit. In addition, retention of the core will be enhanced, as will retention of the final restoration to the core if a resin-based luting cement is used. The greater translucency of a composite core might be considered an advantage, although this is of less significance in posterior teeth compared with anteriors.

Some of the negative features of resin-based composite are its inferior physical properties (relative to amalgam), polymerisation shrinkage, hydroscopic expansion as a result of water adsorption, and incorporation of voids in the build-up because it cannot be condensed like amalgam. Furthermore, resin-based composite is incompatible with the zinc oxide eugenol (ZOE) found in many root canal sealers, which can result in resin that is not cured completely. It can also be difficult to identify where a tooth-coloured composite core ends and the tooth begins. This is rarely a problem with amalgam and, accordingly, the operator can be sure that his or her margins are placed beyond the core and onto sound tooth structure.

These negative features may lead to microleakage if they are not addressed properly during placement of the material. Proper removal of the residual root canal sealer coupled with a small incremental build-up using a condensed resin-based composite material may help alleviate the potential of microleakage.

In spite of concerns over the mechanical properties of composite (relative to amalgam), one in vitro study (Pilos R et al, 2002) comparing resin-based composite, amalgam and cast gold as a core material under a crown in root-filled teeth found no significant difference in fracture and failure characteristics among these materials, provided a 2mm ferrule existed on the margin of healthy tooth substance.

Glass ionomer cement, on the other hand, was shown to be weak in tensile and compressive strengths, and it had low fracture resistance as a core material in another study. Glass ionomer cement has also been shown to exhibit a low modulus of elasticity, poor bonding characteristics to dentine and enamel, poor condensability, and high solubility (Millstein PL et al, 1991). Therefore, the use of glass ionomer cement as a core material should be avoided.

References


Figures 4a and 4b: Amalgam onlays are extremely durable provided there is a sufficient bulk of material overlaying the cusps (image courtesy of Dr Jason Smithson)