Fibre posts and tooth reinforcement:
Evidence in the literature

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Traditional thinking that a post is only placed to retain a core and serves no other purpose may no longer be valid.1

The preservation of dentine during access opening, shaping the canal, preparing the root for placement of a post, and during restoration with an onlay or full coverage preparation is critical to the clinical longevity and success of the final restoration.2 It is now well recognised that excess removal of dentinal support, not only in the root, but also coronally, changes the flexural behaviour and resistance to failure, and that over-flaring the canal for straight line access to the canals weakens the dentinal complex.3–6 Dentine coronally must be maintained, not only to give support to the core build-up,7,8 but also because clinical and in vitro studies support the fact that survival of endodontically treated teeth restored with posts is directly proportional to the residual coronal dentine that remains.3,10 Post preparation of the root canal space must not remove additional dentine, as this contributes to a reduced fracture toughness (Fig. 1). Ree et al. state that 'no additional dentin should be removed beyond what is necessary to complete the endodontic treatment'.11 If this concept is to be adhered to clinically, then of course the use of parallel sided posts must be eliminated from our clinical protocol, as these posts usually require removal of sound apical radicular dentine, creating sharper internal line angles, resulting in a weakened root and a higher root fracture risk (Fig. 2). Moreover, the parallel post does not complement the tapered shape of the prepared canal, resulting in excess luting composite in the coronal aspect of the canal, which can decrease bonding efficacy and decrease dislocation resistance (Fig. 3).13 If we adhere to the concept of minimal dentine removal in the root, and if we recognise that most root canals are ovoid in shape, then a wholly different treatment approach than what we have been taught in the past is indicated. Boksman et al. have recommended utilising a tapered master quartz fibre post (Macro-Lock Post Illusion X-RO, RTD St. Egreve, France) with additional Fibercones (RTD St. Egreve, France) placed into the irregularity (lateral spaces) of the canal (Figs. 4 & 5).14 This technique is similar to using a master gutta-percha point with accessory gutta-percha points, which is well-understood. Utilising this approach provides several clinical advantages,15–19 including more anti-rotational resistance, decreased volume of composite or cement lateral to the post to decrease the C and S Factor constraints (volumetric shrinkage), better adhesion to the root canal walls resulting in decreased microleakage and increasing resistance to dislodgement, as well as increased likelihood for lateral perforation. The combination of a post, or multiple posts, that transmit light efficiently, with sufficient extended light curing
The indirect cast gold/metal/zirconia post and core has been largely replaced with a one appointment restoration of a direct post and core. Fibre posts such as the Ultradent Unicore Fiber Post, the quartz fibre posts manufactured by RTD (St. Egreve, France), the Macro-Lock X-RO (RTD St. Egreve, France), and the DT Light-Post (RTD St. Egreve, France) have many physical characteristics that make them more desirable clinically, rather than metal and zirconia posts:

1. The elastic modulus (or a material’s stiffness) of fibre posts more closely approximates that of dentine (18.6 Gigapascals—GPa) allowing some slight flex in function, dissipating stress and reducing the likelihood of damage to the root.\(^{20,21}\) Stainless steel has an elastic modulus of about 200 GPa, titanium alloy 110 GPa and Zirconia 300 GPa.\(^{22}\) The stiffness of metal and zirconia posts creates more internal stress, zones of tension and shear during function and parafunction,\(^{23}\) which can result in unrestorable catastrophic root fractures.

2. Fibre posts have a high flexural strength, and in a study by Stewardson, ‘the flexural strength of fibre reinforced composite endodontic post materials exceed the yield strength of gold and stainless steel and two of the FRC (fibre reinforced composite) posts were comparable to the yield strength of titanium’.\(^{24}\) It must be noted here that not all fibre posts are created equal. There are differences in fracture load, flexural strength, fibre diameter, fibre/matrix ratio, type of fibre (with quartz fibre posts having higher failure resistance), light transmission, shape, post surface adhesion, quality of fibre, structural defects/voids and manufacturing quality, which all affect the clinical outcome and longevity.\(^{25–29,16}\) The clinician must make an informed choice for choosing a fibre post—looking for the best attributes above—in order to select the post with superior properties based on independent research. The dental practitioner must also be aware of the best adhesive combinations and techniques, as there are some incompatibilities between dual-cure core materials and simplified acidic adhesives due to residual acidity. There is a variation in the results of the scientific literature when evaluating fibre posts, not only because of the differences in the posts themselves, but also because of the cementing/bonding/adhesive systems used. To date, multiple articles in the scientific literature support the statement that ‘only specific combinations of dentin adhesives and luting cements prove efficient, with total etch adhesives combined with dual-cure cement (composite) appearing to be the best choice’.\(^{30,31}\)

3. Fibre posts are not subject to galvanic or corrosion activity. The corrosion of base metals predisposes to a high percentage of failures with cast posts, which can also create a negative aesthetic outcome of a dark root and darkening of the gingival collar (Fig. 6a).\(^{32,33}\) Milnar and others have published excellent papers showing that the use of a light transmitting post can eliminate this common aesthetic challenge, allowing not only light transmission down the canal eliminating the dark gingival colour, but also the creation of superb clinical aesthetics with translucent ceramics over a composite core (Fig. 6b).\(^{34–36}\)

4. Clinically, heavily restored teeth may hold up to normal occlusal function but many fail in cyclic fatigue—repeated functional stress and torque.\(^{21}\) Fibre posts are more fatigue resistant than metal posts, and the quartz fibre post is found to be more than twice as fatigue resistant as the stainless and titanium alloy posts.\(^{37}\) During repeated fatigue loading, the flexural strength of metal posts can decrease by 40%, while there is only a 14% decrease in a fibre composite post.\(^{38}\)

5. Endodontic procedures do fail, either due to faulty technique, the inability to access or completely de-
Bride a canal, microleakage/bacterial contamination/exposure to endotoxins after endodontic therapy is performed, but before a final restoration is placed (all endodontic procedures should be followed by immediate restoration), or due to failure and microleakage of the coronal restoration. It has been estimated that 25% of re-treatments involve the presence of a post. Fibre posts are atraumatically removed in a matter of a few minutes with available proprietary removal drill systems.

No discussion of the restoration of a badly broken down endodontically treated tooth would be complete without discussing the concept of the circumferential ferrule, which is defined as 'a metal band or ring that encircles the tooth in order to provide retention and resistance form, as well as protect the tooth from fracture.' Most of the published articles, based on in vivo and in vitro data, suggest that a 2 mm ferrule is best for improving resistance to fracture with significant decreases when the ferrule is 1 mm or non-existent. However, it is not only the height of the remaining dentine that is critical for creating the ferrule, but just as important is the width of the remaining dentine and the number of walls. As shown in Figures 7 and 8, there is a drastic difference in outcomes when preparing a ferrule in a modestly flared canal versus a wide flare. As can be seen, when a wide flare exists, the preparation of a ferrule actually removes the dentinal lateral walls, creating a standalone core that essentially has no ferrule at all. It is important to note here that glass ionomer cements and resin modified glass ionomers lack the physical properties to function as a core material. Jotkowitz et al. in their article on 'Rethinking the Ferrule', provides one of the best regression analyses and clinical guidelines in the literature, evaluating the effects of the height, number of walls remaining, thickness of the walls, and whether a mesial/distal or buccal/lingual wall is remaining in relation to the functional stresses involved. A simple example would be the difference of losing a lingual wall on an upper central—even if three walls remain—which can be catastrophic due to the torque placed on the lingual in function, as opposed to losing an interproximal wall that has little weakening effect when lingual stress is applied. Their conclusion is that no ferrule equals unrestorable. 'Clinical protocols should feature well-defined inclusion criteria, including delineation of the number of residual coronal walls, for a clearer assessment of the influence of the remaining tooth structure on treatment outcomes.' As the number of remaining walls decrease, the fracture resistance decreases when no post is used, but the fracture resistance is increased significantly when fibre posts are placed—except when there is no wall left. The success rate for all posts decreases drastically in the absence a residual coronal wall.

The literal definitions of reinforcement from various sources includes:
- A device designed to provide additional strength.
- To strengthen by adding extra support.
- To make stronger.
- To strengthen with some added piece, support or material.
- To make a structure stronger.

Much of the dental literature and texts from the 1970s to the early 1990s indicate that a post is placed when there is insufficient structure left to retain a core/crown, and that metal posts do not reinforce the root. Retrospectively looking at research on endodontically treated teeth utilising metal posts certainly support this finding. However, more recent research articles and publications are creating a body of work that fibre posts do indeed make the root more resistant to fracture and may strengthen the root. What follows is only a partial list, with short summa-
ries of some of the more recent relevant studies supporting the notion of reinforcement by using fibre posts.

D’Arcangelo et al.59 studied the fracture resistance and deflection of teeth restored with a fibre post and prepared for veneers. Seventy-five human maxillary central incisors with similar anatomic crowns were included: no preparation, veneer preparation, endodontic access filled with composite, endodontic access with composite and veneer preparation, and fibre post placement (RTD Endo Light Post) followed by veneer preparation. All specimens were thermo-cycled and submitted to fracture strength tests by using a displacement measurement system. Preparation for veneers increased the deflection values of the specimens, but the fibre reinforced post restoration with veneer preparations did not show statistically significant differences from the intact unprepared incisor.

When investigating the fracture resistance and failure mode of premolars restored with composite resin and various prefabricated posts, Hajizadeh et al.1 utilised 60 extracted teeth with four subgroups: no cavity preparation, endodontics with an MOD and no post, endodontics with a DT Light Post (RTD) and MOD, and the last group with endodontics, Filpost (Filhol Dental, UK) and an MOD composite restoration. The teeth restored with the DT Light Post and composite were as strong as the control (the unprepared tooth) and stronger than those teeth restored with composite alone without a post, and those restored with a titanium post and composite. In the DT Light Post group, 86% of the fractures were ‘restorable’, which was much higher than any of the other three groups. According to the authors, ‘There is growing evidence that fibre posts provide the additional benefit of increased fracture resistance’.

The effect of placing fibre posts under zirconia-ceramic crowns was studied by Salameh et al.60 Ninety mandibular second molars were divided into three test groups, representing various extents of coronal damage, endodontically accessed and obturated with warm vertical condensation. Half of the specimens were restored with composite, the other half with a translucent FRC post (Rely-X Fiber Post, 3M ESPE) with a composite core. The insertion of the fibre post improved the support under the zirconia crowns, which resulted in higher fracture loads and favourable failure type compared to a composite core build-up.

Maccari et al.61 utilised 30 single rooted endodontically treated teeth to evaluate the fracture resistance of different prefabricated aesthetic posts. Included in the study were Aestheti-Post (RTD), FibreKor Post (Jeneric Pentron) and CosmoPost (a ceramic post system from Ivoclar Vivadent). They summarised that the mean fracture resistance of the glass fibre prefabricated aesthetic posts proved a higher fracture resistance than the ceramic post, which was less than one half of the fibre posts.

The fracture resistance and failure pattern of endodontically treated maxillary incisors restored with composite resin, with and without fibre reinforced composite posts under different types of full coverage crowns, was studied by Salameh et al.62 One hundred and twenty maxillary incisors were endodontically treated and divided into four groups of 30 each and further divided into two subgroups of restoration with or without a fibre post (Postec Plus, Ivoclar Vivadent). Restorations placed were PFM, Empress II, SR Adoro crowns and Cercon crowns, with all preparations including a 2 mm ferrule. Fracture tests showed that the type of crown was not a significant factor affecting the fracture resistance, but the presence of a post was.

Fig. 6a: The common aesthetic failure when using metallic posts with discoloration of the tooth structure, as well as the gingival collar. (Courtesy of Dr Frank Milnar)

Fig. 6b: The result of placing a light transmitting fibre post with a translucent ceramic. (Courtesy of Dr Frank Milnar)
The authors state that ‘although prosthodontic textbooks do not generally advocate the placement of fibre posts in endodontically treated incisors, the results of this study indicate that the use of fibre posts in such teeth increases their resistance to fracture and improves the prognosis in case of fracture’.

In a study of 80 endodontically treated maxillary premolars treated with or without fibre posts, and MOD cavity preparations restored with different types of crowns, including porcelain fused to metal, lithium disilicate, fibre reinforced composite or zirconia crowns, Salemeh et al \(^63\) loaded the restorations until failure, recording the maximum breaking loads. Under vertical loading conditions, the fracture loads of teeth restored with fibre posts were significantly greater than those without posts, and the fibre posts significantly contributed to the reinforcement and strengthening of pulpless teeth by supporting the remaining tooth structure against vertical compressive stresses.

There are many more studies showing the reinforcement of tooth structure with fibre posts.\(^64–73\) It is impossible to summarise them all, but it seems obvious that our concept of restoring endodontically treated teeth is continually advancing as new products and bonding techniques evolve. Even when there are variations in the types of fibre posts used in the studies, and different cementation and adhesive protocols, there is compelling evidence that fibre posts can reinforce tooth structure.

To create balance in this overview of the literature, it must be said that there are of course some published scientific articles that do not show a reinforcing effect of fibre posts.\(^7,74,75\)

In addition to the traditional definition of mechanical reinforcement: restoring a compromised tooth to a fracture strength equal to or greater than its original ‘untreated’ fracture resistance, we clinicians perhaps should be more focused on the predictability of outcomes, particularly in worst-case scenarios. That is the contribution of the post versus no post, or composite only, to the remaining structures. The most predominant conclusion emerging from the growing body of \(in vitro\)\(^76–79\) (and clinical) data is that failures of fibre posts \(in situ\) are more likely to be described as ‘non-catastrophic’ or ‘repairable’, which is usually not the case with high modulus posts.

Furthermore, recently published clinical trials correlate the success rate to the number of remaining dentine walls.\(^51,80,81\) Variations in the literature on fibre posts are the results of: use of natural teeth or bovine teeth; \(in vivo versus in vitro\) results; the effect of the periodontal ligament in distributing some of the stresses; loading technique (vertical, horizontal or at an angle); the type and quality of the post; the recognition of the ‘secondary smear layer’ and how it affects adhesion; the type of radicular dentine that is to be bonded; the adhesive used; the light carrying or transmission capability of the post; the type of composite used to cement the post; the amount of com-
posite lateral to the post; the filler loading of the composite; and the amount of critical dentine that is removed to place the post.

Adhesive bonding in the root canal has its unique challenges due to dentinal structure in the canal (coronal dentine bonds better than apical dentine), the ‘secondary smear layer’ of debris from gutta-percha and sealer that compromises the ability of simplified systems to actually bond to the root surface (results in mainly frictional resistance), C and S Factor polymerisation effects, curing to depth when using dual-cured composite (all dual-cured composites have a higher polymerisation percentage when exposed to sufficient light) resulting in better overall physical properties, and material incompatibilities.

Fibre post restoration techniques require a meticulous protocol and the clinician is urged to scour the literature, not only for the best fibre post available but also the best techniques for placement. Materials and techniques for fibre post restoration of endodontically treated teeth are continuously evolving, with the inevitable outcome of better clinical results for our patients.

Editorial note: A complete list of references is available from the publisher.

Disclosures

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