Rationale for the suggested use of fibre post segments in composite core build-ups for endodontically treated teeth

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The restoration of teeth utilising composites still presents a myriad of clinical challenges for the dental clinician. This is especially true for extensively broken down teeth and as well, those teeth which have been accessed endodontically. Fibre posts such as the quartz Macro-Lock Illusion X-RO post (Recherches Techniques Dentaires—RTD) UniCore Fiber post (Ultradent), and DT Light-Post (RTD) are now the posts of choice for a direct one appointment restoration of the severely compromised endodontically treated tooth. Current research supports the use of an etch and rinse bonding protocol, with a compatible bonding agent, utilising a dual-cured composite cement that can be utilised for the core as well (Cosmecore—Cosmedent; CoreCem—RTD; Zircules—Clinician's Choice) for best results.[1,2] Traditionally, minimally accessed endodontically treated teeth that are not extensively compromised by caries or fracture, have been restored solely with a composite core, without the placement of a post. This decision must be based on the amount of tooth structure left, and if a full coverage restoration is to be placed now or in the future. The width and height of the ferrule remaining is critical to restorative success (Figs. 1a & b),[3-6] as well as the number of tooth walls left, post preparation, which significantly affects the long-term restorative outcome (Fig. 2).[6-8]

In a review of 41 articles published between 1969 and 1999 (the majority from the 90s), Heling states that 'the literature suggests that the prognosis of root canal-treated teeth can be improved by sealing the canal and minimising the leakage of oral fluids and bacteria into the peri-radicular areas as soon as possible after completion of root canal therapy.'[9] A similar review by Saunders et al also concluded that coronal leakage of root canals is a major cause of root canal failure.[10] Sritharan states that 'it has been suggested that apical leakage may not be the most important factor leading to the failure of endodontic treatment—but that coronal leakage is far more likely to be the major determinant of clinical success or failure.'[11] Coronal microleakage can occur due to a deficient final restoration (due to resultant microleakage from polymerisation contraction, cement wash out, poor full coverage, flex etc) and resultant secondary caries.[12]
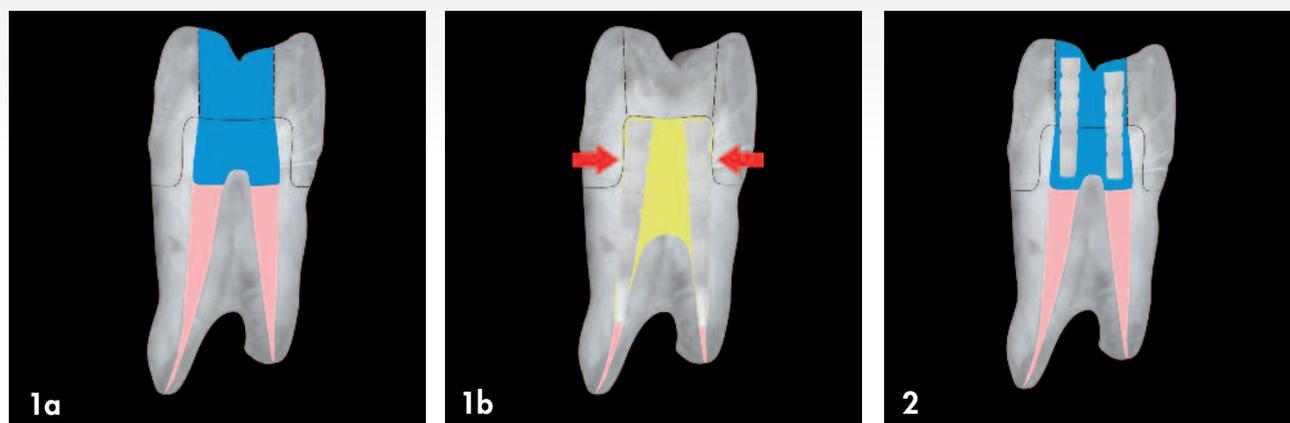
Fig. 1a: Schematic diagram of a molar with conservative access opening, which when restored with a core only, will leave sufficient width and height of dentin to act as a ferrule resisting failure.

Fig. 1b: The same tooth with a widely divergent access opening, restored with Macrolock posts and composite core, when prepared for a full coverage restoration will not leave sufficient dentine (no ferrule), resulting in a stand-alone core which will drastically influence failure rate.

Fig. 2: Schematic diagram of the molar in Figure 1a, but with Macrolock Fiber Post segments as inserts to decrease composite volume and increase polymerisation factors.

Polymerisation contraction (shrinkage)

Many different types of composites are now available to the practitioner including microfills, macrofills, hybrids, and small particle hybrids, nanofills, nanohybrids, or microhybrids.[13] Even though the formulations can be adjusted in handling to make these composites 'packable', 'flowable', or 'sculptable', polymerisation shrinkage or contraction stress is still the most important clinical challenge or problem associated with their use.[14,15] This shrinkage or contraction and the stress created varies from composite to composite, and can be affected by: its filler type and loading content, the resin matrix and its molecular weight, the shade and opacity, the cavity preparation shape (C-Factor) width and depth, the composite thickness, the elastic modulus of the composite and tooth, the irradiance level and curing time, the spectral output of the curing light, the curing light placement, bulk or incremental fill, the rate of force development (high irradiance lights), the initiator system used, and the degree of conversion.[16-25] In published studies, shrinkage values for various composites have been reported from 2.00 to 5.63 vol. per cent,[26] and 1.67 to 5.68 per cent,[27] with flowables demonstrating the highest shrinkage with a contractions stress measurements ranging from 3.3 to 23.5MPa.[26] Not all composites advertised as low-shrinkage actually have reduced polymerisation shrinkage measurements. When evaluating seven low-shrink BisGMA-based composites, Aelite LS Posterior and N'Durrance presented relatively high shrinkage values.[28]

The polymerisation contraction of the composite resin and contraction stress created, as discussed previously, can produce tensile forces on the tooth structure and the bonding system that may not only disrupt the bond to the cavity walls,[29,30] but also fracture enamel along the prisms (white line margins).[31] This failure can lead to caries, sensitivity in vital teeth, and microleakage, allowing the penetration of bacteria, fluids and toxins which can negatively affect the success of endodontic treatment (coronal leakage).[32] Braga et al state that 'shrinkage stress development must be considered a multi-factorial phenomenon' and that 'the volume of the shrinking composite becomes a variable to be considered'.[33] Unterbrink and Liebenberg in their publication state that shrinkage stress increases with increasing C-Factor and that the size of the restored cavity is an important factor when bulk filling.[34] Their study[35] also shows that incremental filling lowers the C-Factor and that it is better than bulk cure because of better adaptation to the cavity wall, decreasing microleakage and increasing the degree of conversion. In a study looking at microleakage and cavity dimensions, it was found that microleakage seemed to be related to a restoration's volume, but not to its C-Factor.[36] With bulk filling techniques, the hardness or conversion of composites are significantly lower than those of the same material placed

Fig. 3: Radiographic presentation of a patient with pain in the lower left second molar, which has been minimally restored.

Fig. 4: The clinical presentation of the second molar which would demonstrate sufficient tooth structure remaining after root canal treatment so that a fibre post and core is not required.

with the incremental technique.[37] Watts et al[38] recommend that the restorative mass must be equally considered when translating shrinkage science into specific clinical recommendations.

So where does this lead us in a suggested modification of our restorative technique for placing a core in an endodontically treated tooth? Currently, when there are enough walls and tooth structure left, many clinicians insert a bulk fill, dual-cure composite resin into the endodontic access opening (the same material as that used for cementing the fibre post) and then cure it all at once with an LED curing light. As already mentioned, this bulk fill not only creates a challenge for proper depth of cure and maximum physical properties on polymerisation, which will be addressed later in this article, but the large volume/amount of composite inserted, negatively affects the integrity of adhesion and increases microleakage. The typical access opening, which is essentially a very deep Class I cavity preparation, not only requires a large amount of composite, but as well, places the composite in the highest C-factor cavity preparation configuration of five. Only when utilising a composite deep in the prepared root canal, has the C-Factor claimed to be higher at 200 to infinity.[39]

The suggested solution to the high polymerisation and contraction stress caused by bulk filling the access opening is to reduce the mass or bulk of composite by placing multiple Fiber Post Segments into the composite mass, before curing with the LED light. It has been conclusively shown that even when the C-Factor is at 200 or more in a prepared root

canal, minimizing the thickness of the composite (the mass), results in less contraction stress (S-Factor) which increases the patency of the bond to the root canal walls decreasing microleakage.[40-43] Of course, the placement of inserts into composite is not a new idea. Glass ceramic inserts and beta quartz have been used to decrease composite volume and later silica glass and ceramics were introduced as a method for post-composite insertion bulk reduction.[44-46] These techniques demonstrated increased marginal patency and less microleakage, but the inserts were difficult to contour and polish with adhesion between the inserts and the composite being a challenge.[47,48] Composite megafillers were introduced later, as these were essentially the same as the matrix of the bulk filled composite, eliminating the inherent chemical differences between the materials.[49,50] The authors suggest the insertion of multiple high quality, high capacity, light conducting fibre post segments (not all fibre posts conduct light efficiently[51,52]). This is not only to reduce the composite volume, thereby minimizing the potential for microleakage, but is also equally as critical to use the light conductance of the fibre post segments to significantly increase the degree of polymerization of the dual-cure composite resin cements/core materials deep in the access opening, thereby increasing their physical properties.[53]

In their review of polymerisation shrinkage, Cakir et al discuss the attenuation of light, which means that the deeper layers of composite resin are less cured with reduced mechanical properties, and that bulk filling shows significantly less hardness.[54] Others have also shown that

Fig. 5: Magnified view of the distal ridge of the second molar demonstrating a vertical crack.

Fig. 6: Completion of the debridement of the canals after rubber dam isolation with a better view of the extent of the distal crack line.

Fig. 7: The root canals have been obturated with gutta percha, a couple of mm below the level of the pulpal floor.
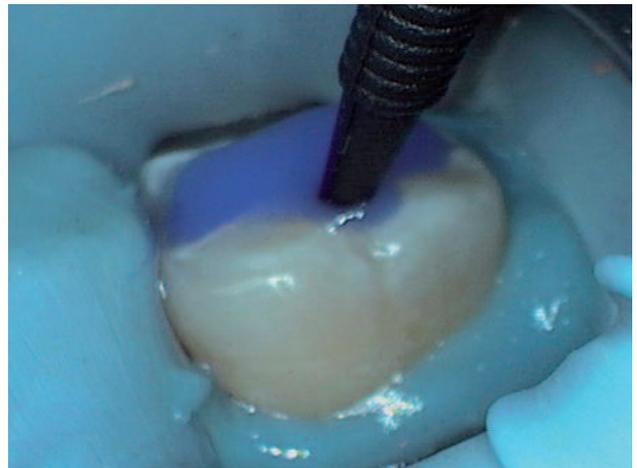

Fig. 8: After placement of the phosphoric acid (UltraEtch Ultradent) a microbrush is used to agitate the acid to clean the dentin, rinsed and lightly dried.

bulk placement and increased cavity depth result in a significant decrease in the effectiveness of polymerization, regardless of the exposure time.[55] The ADA Professional Product review on Restorative Materials evaluated the depth of cure of 38 restoratives with ranges of 1.2 to 5mm. with a core material CompCoreAF syringMix Flow (W) being the lowest depth of cure at 1.2mm. Included in the study were measurements of maximum polymerisation shrinkage stress showing that LuxaCore Dual Smartmix W was the highest in stress MPa of the core materials tested, with Clearfil Photo Core (T) showing the highest development of shrinkage stress rate.[56]

Dual cure composite materials show the best physical properties and best polymerisation with sufficient light exposure, even though they are claimed to polymerise in the absence of light[57-61] and 'there is no evidence for a substantial chemically induced polymerisation of dual cure resins that occurs after light exposure is completed.'[62] This reality is especially critical for dual-cure self-adhesive resin cements Maxcem and RelyX Unicem, which show a better degree of conversion when they are light activated, with a lack of light activation decreasing the monomer conversion by 25 to 40 per cent[63] and even in their dual cure mode, the decree of cure at best among the self-etch adhesives is

Fig. 9: MPa bonding agent is applied to a microbrush and agitated into the tubules, followed by evaporation of the solvent with an air-only line.
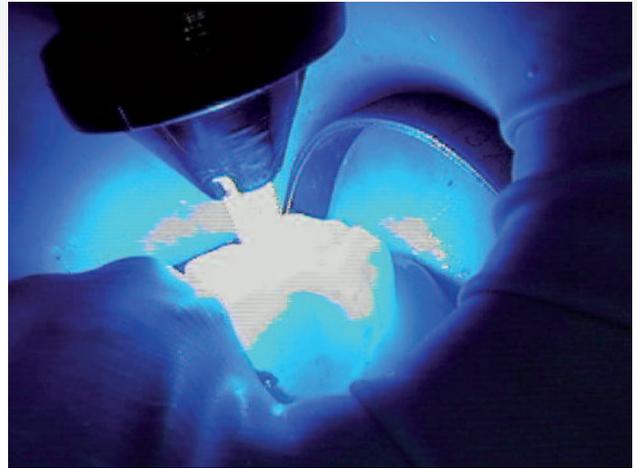

Fig. 10: The bonding agent is cured for 10 seconds with a Valo curing unit (Ultradent).
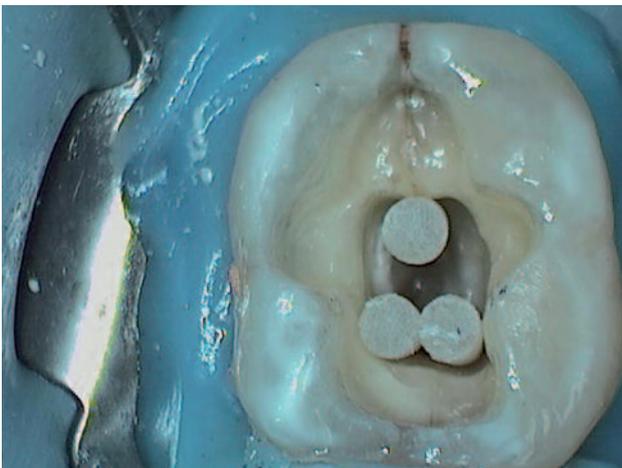

Fig. 11: Multiple MacroLock X-RO (Clinical Research Dental) fibre post segments (covered with a bonding agent which is first light cured) are verified for fit into the distal and two mesial canals.

Fig. 12: The Cosmecore A2 is injected into the bottom of the pulpal area filling to one half of the crown height, followed by the placement of the MacroLock X-RO segments at the canal orifices.

only 41.52 per cent.[64-66] Thus, the placement of a bulk filled dual cure composite into the endodontic access opening, followed by the placement of multiple fibre post segments that carry sufficient light energy to the depth of the occlusal floor of the access preparation, will increase the polymerisation conversion, resulting in a composite that demonstrates superior physical properties.

As a final comment, it has been proven that immediate high intensity light polymerisation creates the greatest polymerisation stress. Ilie et al state that 'fast contraction force development, high contraction stress and an early start of the stress build up cause tension in the material with possible subsequent distortion of the bond to the tooth structure'.[67] This finding has been collaborated by many others in the scientific literature with resultant recommendations for a soft start or lower energy over a longer period of time.[68,69] Miller states that 'manufacturers continue to make outlandish claims of their curing capabilities, most of which fall into the 'too good to be true' category'[70] and Swift concludes that 'the curing times recommended by a manufacturer might not deliver the amount of energy required to adequately cure composite, even under the ideal laboratory conditions' that 'very short
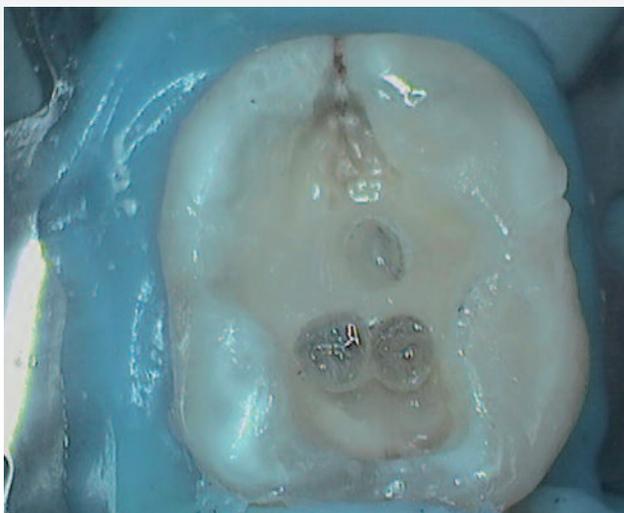
Fig. 13: Occlusal view of the Cosmecore placed half way up the coronal tooth structure with the three segments placed. This first layer was light cured and followed with the completion of the final Cosmecore layer cured for 20 seconds.
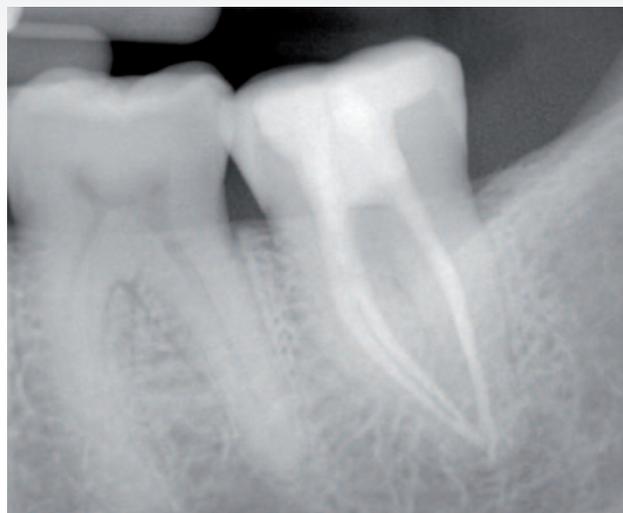

Fig. 14: Post-operative radiograph of the completed restoration.

curing times are not a good idea in most clinical situations' and that 'longer curing times are required'.[71]

As well, Swift states that 'instead of obtaining a boost, the "turbo" tip actually will reduce the amount of light reaching the composite to initiate the polymerisation process.'[72]

Clinical case

A 64-year-old female presented to the endodontic office with an uneventful medical history. She complained of spontaneous pain on the lower left side of one week's duration, which radiated up the ramus of the jaw and was causing headaches. She also complained of hot and cold sensitivity with pain on biting. Clinical tests revealed pain to cold, which lingered for five minutes and a sharp electric like pain when a tooth sleuth was placed over the DL cusp tip. A distal crack was visualised. There was no periodontal pocketing. All other mandibular left and maxillary left teeth tested vital and asymptomatic. The radiograph revealed a small shallow minimally invasive amalgam restoration (Fig. 3). The diagnosis was Cracked Tooth Syndrome with an irreversibly inflamed pulp. The patient was advised of the questionable long term prognosis with cracked teeth yet decided to try and retain it understanding that if the crack extends in the root proper and a periodontal pocket develops, then extraction with an implant replacement may be a viable solution.

Due to the minimal invasiveness of the restoration, it is

anticipated that after endodontic treatment, there would be enough coronal tooth structure left to allow for the preparation of a full coverage restoration with a fully circumferential ferrule of at least 2+mm in height, as well as width (Fig. 4). Figure 5 is a magnified view of the distal vertical crack, with the wear facet on the lingual cusp indicating a working side contact interference. Endodontic therapy was initiated under the microscope and after a thorough debridement and shaping of the root canal spaces (Fig. 6), the roots were obturated with gutta percha using a

Fig. 15: Occlusal view of the final restoration, trimmed and adjusted to the occlusion. The tooth is now ready for a full coverage crown or onlay to protect the clinical crack.

continuous wave of condensation technique to a level 2mm below the pulpal floor (Fig. 7). Phosphoric acid etching was initiated with the placement of Ultra-Etch Etchant (Ultradent) followed by microbrush agitation to work the etchant into the dentine, a thorough rinse, and light air drying (Fig. 8). Figure 9 shows the application of MPa bonding agent (Clinical Research Dental) with a microbrush, which again was followed by agitation to facilitate deeper penetration of the bonding agent, followed by evaporation of the solvent for ten seconds. The bonding agent was cured with a Valo Curing Light (Ultradent) for ten seconds utilising a Valo Proxiball Lens (Fig. 10). The Macro-Lock X-RO segments are verified for fit over the three canal orifices, and then coated with MPa bonding agent, which was cured for ten seconds (Fig. 11). Cosmecore (Cosmedent) A2 is injected into the pulp chamber one half way up the occlusal height of the clinical crown (Fig. 12). The Macro-Lock X-RO segments are inserted into the Cosmecore followed by a 10 second cure with the Valo (Fig. 13). The rest of the occlusal access opening is filled with the Cosmecore and thoroughly cured with the Valo for 20 seconds. Figure 14 is the final post-operative radiograph showing the placement of the fibre segments into the core. The final restoration of the occlusal access opening is shown in Figure 15 after trimming and occlusal adjustment. The endodontically treated tooth is now ready for a final restoration.

This article has recommended restoring the teeth that meet the criteria for not needing the placement of fibre posts because of sufficient remaining tooth structure, with the use of multiple fibre post segments placed into the dual-cure composite cores of endodontically treated teeth based on the above evidence. This will decrease the overall polymerisation contraction and stress formation, thereby reducing occlusal microleakage, while at the same, time driving the dual-cure composite to a better overall cure or conversion for better physical properties.

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