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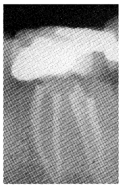

CLINICAL ARTICLE

Influence of surface remodelling using burs on the macro and micro surface morphology of anatomically formed fibre posts

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Abstract

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Aim To evaluate the effect of modifying preformed fibre-reinforced composite (FRC) endodontic posts on their surface morphology and to determine how this procedure affects the integrity of the posts.

Summary Surfaces of 10 preformed glass-fibre posts (group 1) and carbon-fibre posts (group 2) were compared with those of individually formed glass-fibre posts (group 3). Ten FRC posts were modelled in order to give them a shape as close as possible to the anatomy of oval root canals. Starting from a preformed cylindrical fibre post 2.5 mm in diameter, it was modelled in such a way as to passively occupy the entire post-space length, using a cast previously created as a guide. Microscopic analyses (optical stereomicroscope and scanning electron microscope) of the post surfaces revealed similar features in all three groups. All posts had regular surfaces after cutting with a diamond bur. Smear layer mainly attributable to the cutting procedures covered the cut surface of some specimens. In conclusion, modulation of a fibre post using a diamond-coated bur did not show a loss of integrity of the post.

Key learning points

• Because of the importance of micromechanical retention, the surface integrity of fibre posts may be important for adhesion between post and composite resin.

• Modification of a fibre post using a diamond-coated bur did not damage the surface integrity of the posts.

• Fibre posts can be ground to a different shape without losing their surface integrity, resulting in posts with a surface that is not visibly different from unmodified commercially available fibre posts.

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Introduction

Restoration of root-filled teeth may be carried out with or without a post (Fernandes *et al.* 2003). The primary reason for using a post is to retain a core and thus restore the missing coronal tooth structure. Posts do not strengthen the tooth as has been advocated traditionally (Gutmann 1992, Assif & Gorfil 1994).

To achieve optimum results, the materials that are used to restore root-filled teeth should have physical and mechanical properties that are similar to that of dentine, should be able to bond to tooth structure and should be biocompatible in the oral environment (Fernandes *et al.* 2003). Fibre-reinforced composite (FRC) root canal posts have been introduced as an alternative to conventional materials (Duret *et al.* 1990). The biomechanical properties of FRC posts have been reported to be close to that of dentine (Mannocci *et al.* 2001, Lassila *et al.* 2004, Plotino *et al.* 2007). Clinical prospective and retrospective studies on fibre posts have reported encouraging results (Ferrari *et al.* 2000a,b).

When a post is deemed necessary, a choice can be made between anatomical or preformed posts. The selection of a preformed post assumes the need to adapt root canals to posts, whilst the selection of an anatomical post presupposes the preference for a cast material (i.e. gold or other metals) or suitable procedures (i.e. pressure die-casting ceramics) that permit adaptation of the restoration to the shape of the canal (Ottl *et al.* 2002). Nevertheless, the adaptation of the canal shape to the post requires the sacrifice of sound dentine tissue, which conflicts with one of the universally accepted concepts in the restoration of root-filled teeth: prognosis improves proportionally to the amount of sound tooth structure, regardless of the type of restoration that is subsequently provided (Stankiewicz & Wilson 2002). Whilst the clinician can consider preserving tooth structure and cement an undersized preformed post, this will result in a substantial volume of cement around the post. Additionally, preformed metallic or fibre posts either have a circular, progressively tapered or cylindrical shape, yet they are placed in canals that are oval or ribbon shaped (Wu *et al.* 2000). The more oval the canal, the greater the discrepancy between the canal and post, which therefore requires removal of sound tooth structure or placement of a post that is not adapted to the walls of the canal.

Fibre-reinforced composite posts contain a high volume percentage of continuous reinforcing fibres embedded in a polymer matrix, which keeps the fibres together. Matrix polymers are commonly epoxy polymers with a high degree of conversion and a highly cross-linked molecular structure (Lassila *et al.* 2004). Because of the difference in chemistry, no bonding can be expected between the methacrylate-based resin of the composite resin and the epoxy resin of the fibre post matrix (Monticelli *et al.* 2006). Therefore, retention is micromechanical and based on the interlocking of post and resin cement (Vano *et al.* 2006). Because of the importance of micromechanical retention, the surface integrity of FRC posts, defined as a structure of fibres embedded in a resin matrix without defects, may be important for adhesion between post and composite resin.

A chairside procedure has been reported (Grande *et al.* 2006) that permits the use of an anatomically shaped fibre post, by unifying the advantages of a fibre post with those of an anatomical post in oval- and ribbon-shaped canals (Fig. 1). This is possible because of the characteristics of the preformed fibre post, which can more easily be modified than a

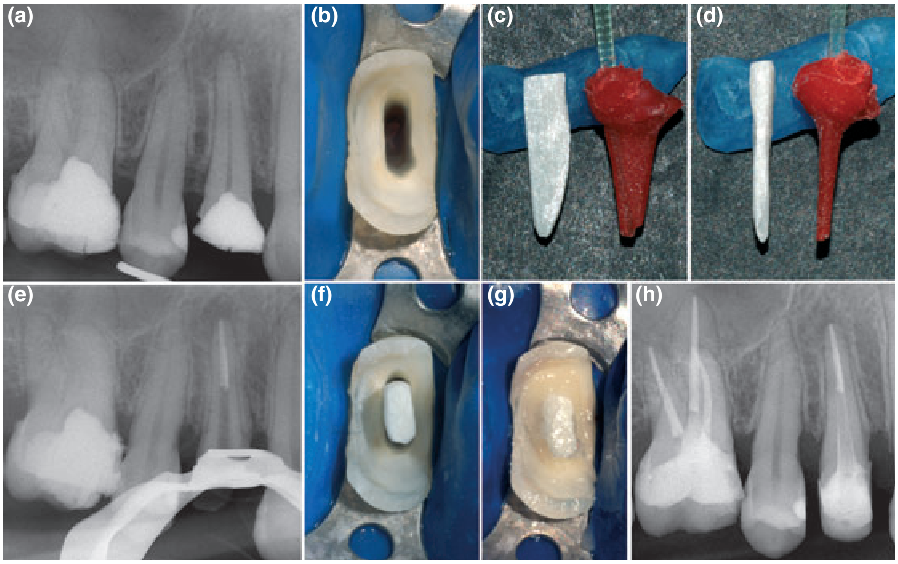

Figure 1 Preoperative radiograph of a maxillary right first premolar that required root canal treatment and a post-retained core prior to placement of a full-coverage restoration (a). The same tooth after preparation of the post-space (b). The anatomical fibre post obtained is compared with the resin impression of the root canal in the mesio-distal (c) and bucco-lingual (d) aspect. Intra-operative radiograph of the prepared post-space (e). The fit of the anatomical post obtained is verified both prior to and following the adhesive procedures (f). It is possible to note the great diameter of the post in its coronal portion, especially in the bucco-lingual dimension. The post was cemented (g) and the core was built up prior to the prosthetic procedures. Postoperative radiograph shows the root canal obturation, the adapted FRC post cemented into the root canal and the resin composite core (h).

metallic preformed posts. A first step in that technique requires the use of a straight low-speed handpiece and medium-grit diamond bur to modify an FRC post of the largest available diameter to a shape approximating the anatomy of the root canal itself. The post has to be modified in such a way as to passively occupy the entire length of the post space.

The aim of this investigation was to evaluate the effect of modifying preformed FRC endodontic posts on the macro- and micro-surface morphology and to determine how this procedure affects the integrity of the posts.

Materials and methods

For this study, three different endodontic posts were selected:
- group 1: glass-fibre posts (Light-Post No. 3; RTD, Saint Egreve, France);
- group 2: carbon-fibre posts (Tech 2000Xop; Isasan, Como, Italy);
- group 3: anatomically modified glass-fibre root canal posts (Periodent, Milano, Italy).

Thirty endodontic posts, 10 for each group, were analysed. Glass-fibre posts (group 1) were a two-stage, almost parallel designed post, with two tapered 'shoulders'. The coronal portion measured 2.1 mm in diameter, the apical portion 1.4 mm with a length of 19 mm. The carbon-fibre posts (group 2) had a diameter of 1.6 mm, a length of 19 mm and a cylindrical shape with a tapered end. The glass-fibre posts were prototypes specifically produced to allow adaptation of the fibre post to the anatomy of the canal (group 3). The posts were cylindrical with a diameter of 2.5 mm and a length of 19 mm.

Ten intact extracted premolar teeth with similar root length (13 ± 1 mm) with an oval-shaped root canal in the coronal and middle third (diameters ratio 3 : 1) were selected to obtain 10 fibre posts that were modified to approximately conform to the anatomy of the

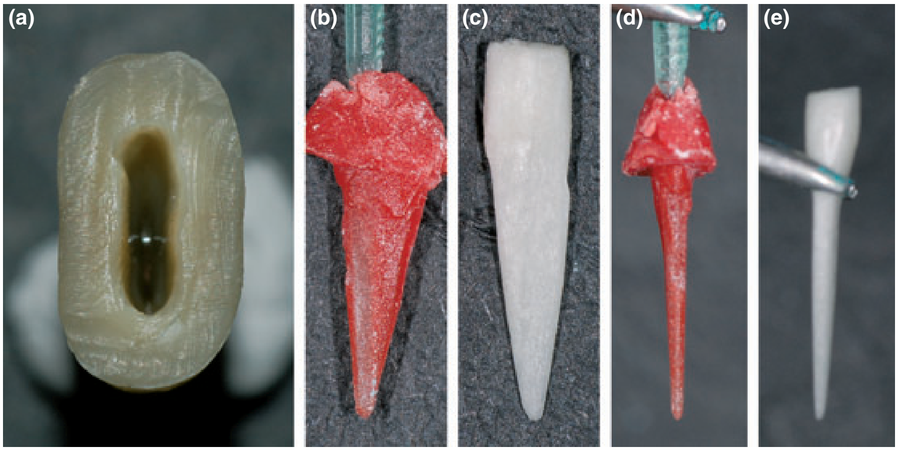

Figure 2 Representative tooth after the preparation of the post space (a). Mesio-distal view of the impression (b) and the adapted post (c) and bucco-lingual view of the impression (d) and the adapted post (e).

root canal. Teeth were instrumented with AET endodontic instruments (Ultradent Products Inc., South Jordan, UT, USA) to a size 40 master apical file and filled with laterally condensed gutta-percha and sealer. The filling material was removed to a length of 8 mm with a Ni–Ti rotary endodontic instrument, specifically designed for post-space preparation (M*two* Post file; Sweden & Martina, Due Carrare, Italy), without enlargement of the root canal. An M*two* Post file size 55, .06 taper instruments with a cutting portion 11 mm long was used at 600 rpm. Canal walls were cleansed using an ultrasonically energized size 15 file instrument under copious sterile water irrigation (Fig. 2a). The post space was then lubricated with glycerine and a plastic pin and autopolymerizing resin (Duralay; Dental Manufacturing Co., Worth, IL, USA) were used to capture the anatomy of the post-space (Fig. 2b,d). Subsequently a mould was created for each duralay specimen using a fast-setting, vinyl polysiloxane impression material contained in a plastic cylinder. The FRC posts were ground to a shape that approximated the anatomy of the canals with a straight low-speed handpiece without water spray, using a medium-grit conical-shaped diamond rotary cutting instrument (Gebr. Brasseler, Lemgo, Germany) (Fig. 2c,e). This procedure was performed at a work station with evacuation, to minimize inhalation of dust. Upon completion, the posts had a passive fit in the vinyl polysiloxane mould. Finally, the samples were rinsed with water and air dried. Posts from groups 1 and 2 were not modified with a diamond bur.

The specimens were observed under an optical stereomicroscope (OSM) at 8×, 16× and 32× magnifications to macroscopically evaluate the surface morphology. The samples were then mounted on a metal stub, gold coated and observed in a scanning electron microscope (SEM) (Philips SEM 515; Philips, Eindhoven, the Netherlands). For groups 1 and 2, attention was focused on the cylindrical and conical surfaces of the fibre posts, whilst in group 3 the cut surfaces were observed. SEM micrographs were made at magnifications of 50×, 150×, 300× and 500×.

Results

Optical stereomicroscope and SEM analyses of the post surfaces revealed similar features in all three groups with the SEM micrographs providing more detail and a greater depth of field at higher magnifications. Uniform results were found according to the type of post analysed.

At low magnification, no macroscopic differences were detected between the three groups when the surfaces were observed with an OSM. Modification of FRC posts did not influence surface macromorphology of FRC posts, which maintained their normal structure (Fig. 3).

Figures 4–6 are representative scanning electron micrographs of samples from groups 1 to 3. At different higher magnifications under SEM analysis, no microscopic differences were found amongst the samples from the three groups. The structure of all types of posts, based on fibres embedded in a resin matrix, was observed. SEM of the parallel surfaces of the posts in group 1 revealed unidirectional fibres running parallel to each other surrounded by the resin matrix, which occasionally lay on the external surface of the post.

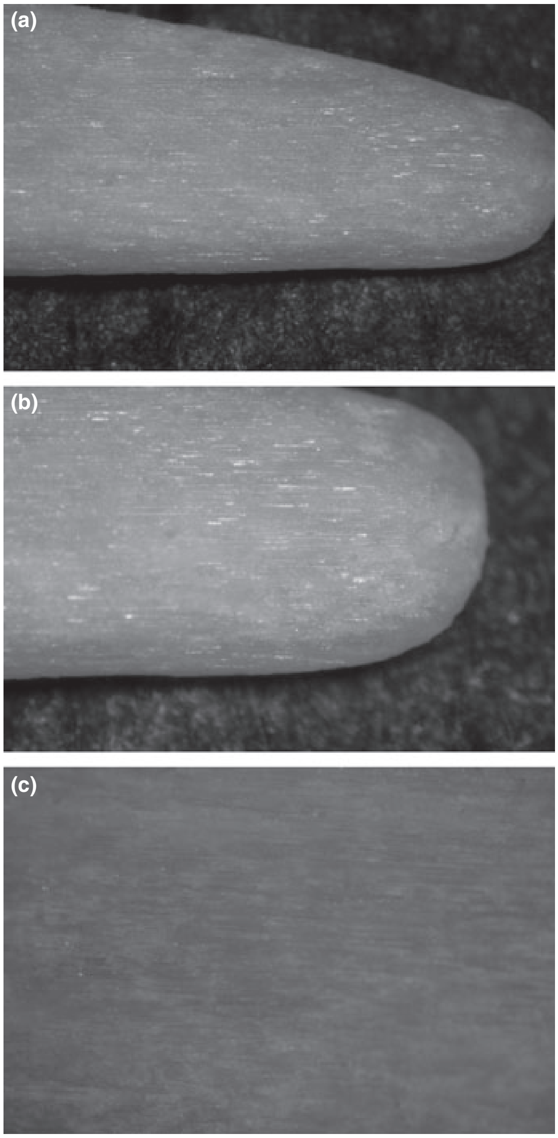

Figure 3 Representative optical stereomicrographs of samples from group 3 at subsequently (a) 8×, (b) 16× and (c) 32× magnifications.

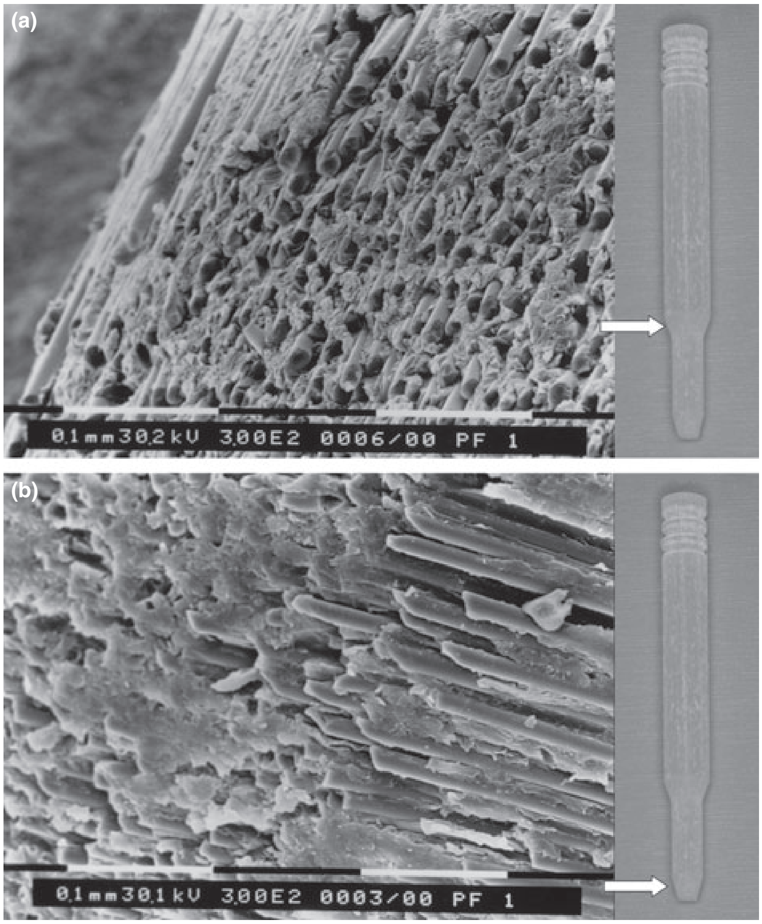

Figure 4 Scanning electron micrograph of the tapered surface of a specimen of group 1 (300×). (a,b) Sheared fibres can be seen protruding from the resin matrix.

The angled tapered surface of the post exhibited a rough surface with bevelled cross-sections of fibre bundles that included fibres unsupported by resin (Fig. 4a). At the tip of the post, the fibres lost support of the resin matrix and were seen extruding from the resin by as much as 0.1–0.2 mm (Fig. 4b).

Figure 5 is representative of the posts in group 2. The fibres also run mostly in a unidirectional parallel fashion with an occasional surfacing of some individual fibres. Of note was the finding that at the surface individual parallel fibre bundles crossed other bundles of similar structure at an angle from 25° to 30° (Fig. 5a). At the tip of the posts of group 2 where the post tapered to a point, the surface was characterized by bevelled fibres stacked in a stepwise fashion.

Figure 6a–d is representative of the modified posts. The mid-sections of the posts revealed unidirectional fibres running parallel and appearing undamaged and embedded in resin matrix (Fig. 6a). No separation of fibres was observed as a result of grinding with the diamond bur. In areas where a lack of continuity of fibres was seen, there appeared to be no difference in surface morphology when compared with groups 1 and 2. Even though the fibres that were cut had a regular appearance in several areas, loss of support from the resin matrix could be seen (Fig. 6b). The modified posts revealed no substantial difference

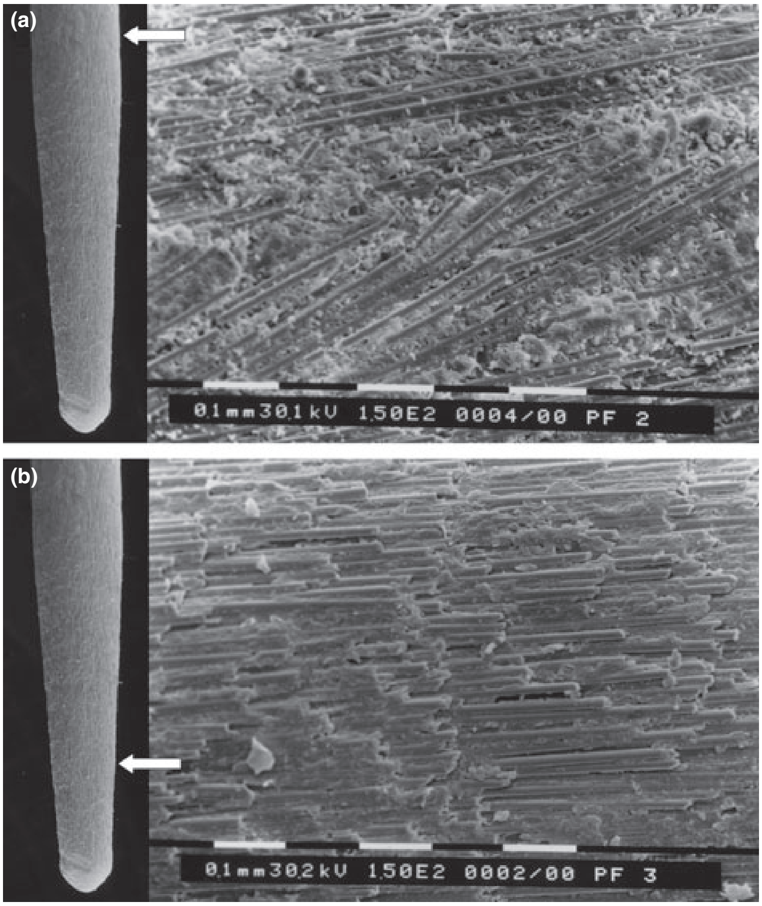

Figure 5 Scanning electron micrograph of the parallel (a) and tapered (b) surface of a specimen of group 2. (a) Surface of the cylindrical portion of the post shows fibres that occasionally are interrupted or are present in a criss-cross fashion (150×). (b) The surface of the conical end portion of the post showed sheared fibres embedded in the resin matrix (150×).

to areas of the tapered portion of posts in group 1 and the parallel side of the posts in group 2 (Fig. 6b–d). The cut fibres appeared to be evenly bevelled (Fig. 6c). Some specimens from group 3 (Fig. 6c,d) demonstrated surface debris with fibres slightly protruding from the resin matrix (Fig. 6b–d).

Discussion

This study aimed to determine whether grinding fibre posts with a medium-grit diamond bur would cause irreversible damage to the post in the form of detachment of fibres from the resin and/or irregular cut fibres. Microscopic evaluation provides an accepted method for analysing the characteristics of a material and can determine its qualitative aspects (Van Meerbeeck *et al.* 2000). The findings of the present study revealed similarities in surface morphology of the three post systems that were examined, in spite of the fact that in group 3 a modification was made with a diamond bur, which was similar to the one that has been described for cutting the coronal portion of fibre posts (Grandini *et al.* 2002) or gutta-percha cones (Lopes *et al.* 2000). As has been demonstrated, fibre posts can be ground to a different shape without losing their surface integrity, resulting in posts with a

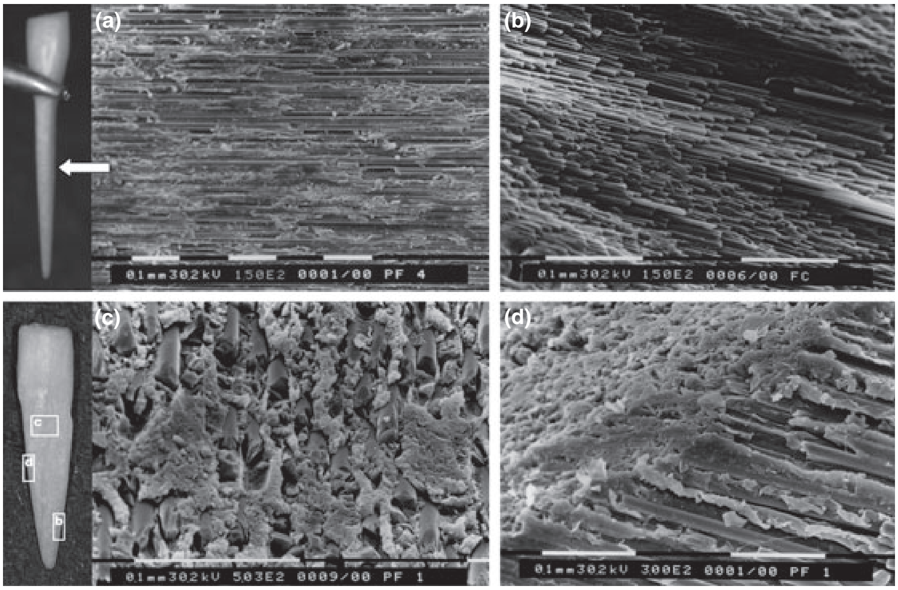

Figure 6 Scanning electron micrograph of the cut surfaces of a specimen of group 3. (a) Parallel cut surface of the post revealed a normal structure with fibres embedded in a resin matrix. The fibres appear to be undamaged from grinding with a diamond bur (150×). (b–d) The tapered cut surfaces revealed features that were similar to those of the untouched fibre posts either at the constriction location or conical end (150×, 500×, 300×).

surface that is not apparently different from unmodified commercially available fibre posts. Cutting fibre posts with a diamond bur creates shear stress on the transverse section of a post; however, the low rpm of the handpiece reduced the plastic deformation of the post (Grandini *et al.* 2002). Therefore, the tensional stress, which was perpendicular to the direction of displacement of the cutting instrument produced by the diamond bur (Grandini *et al.* 2002), allowed for the development of a smooth cut surface.

It would have been logical to assume that the speed at which the cutting was accomplished could have affected the surface characteristics. However, high- and low-speed cutting has been demonstrated to give good results and minimally affected the surface quality of FRC posts (Grandini *et al.* 2002). A diamond bur in a low-speed handpiece was used in the present study because in a pilot study FRC posts that were ground with a high-speed handpiece without water cooling occasionally resulted in burnt fibres. Furthermore, in the present study, the posts were intentionally cut without water spray as several articles have reported that humidity can alter the mechanical properties of fibre posts (Mannocci *et al.* 2001). It remains to be established that the use of water cooling during modification will affect the mechanical properties of fibre posts.

Discontinuity of fibres in the external layer may be a concern and affect the mechanical properties of FRC root canal posts. But even untouched preformed FRC posts revealed a lack of continuity in the external fibre layers as has been observed in posts with serrations (Le Bell *et al.* 2004). Lassila *et al.* (2004) reported no significant differences in the flexural properties of the same posts with and without serration. These results imply that superficial interruption of fibres on the post surface does not influence the mechanical properties of FRC posts. Furthermore, as no loss of integrity of the posts after modification was observed, some discontinuity of the external layer of fibres, as seen in the untouched preformed posts, will not influence the bond between the post and the luting and core material (Le Bell *et al.* 2004, Monticelli *et al.* 2006, Vano *et al.* 2006).

The presence of a smear layer and residual debris resulting from the modification required a hydrogen peroxide etching procedure to clean the surface and thus improve the micromechanical retention between the fibre post and luting and core materials (Monticelli *et al.* 2006, Vano *et al.* 2006).

The anticipated advantages of the technique that was investigated in the present study were as follows.

1. First and most important is the preservation of tooth structure (Raiden *et al.* 1999, Pilo & Tamse 2000). A modified FRC post adapts to the root canal rather than adapting the root canal to the post, usually by enlarging it. This is a significant advantage as after endodontic treatment root canals are usually oval rather than round (Grandini *et al.* 2005).

2. An anatomically adapted fibre post significantly reduces the thickness of the cement layer (Grandini *et al.* 2005), thus reducing polymerization stress caused by a large amount of cement around a post (Ferracane 2005).

3. The formation of bubbles or voids, representing areas of weakness within the material, is less likely to occur in a thin and uniform layer of cement (Grandini *et al.* 2005). If a post does not fit well, especially at the coronal level, the cement layer may be too thick and bubbles are likely to be present (Grandini *et al.* 2005).

4. A thin and even thickness of a cement layer and the absence of voids increase the retention of the post, thus reducing the risk of debonding (Goracci *et al.* 2005, Pirani *et al.* 2005). It has been reported that debonding is more likely to occur in excessively thick layers of cement or in weak areas within the material such as in presence of air bubbles (Ferrari *et al.* 2000a,b).

5. The thicker portion of the extraradicular anatomically adapted FRC post could preserve the margin on the tension side from opening during cyclic load and the margin on the compressive side from crushing cement and dentine, thus maintaining marginal integrity under function (Standlee & Caputo 1988, Assif & Gorfil 1994). Moreover, insufficient post stiffness will lead to excessive deformation of the post and localization of stresses during function, allowing marginal failure (Standlee & Caputo 1988).

6. Finally, some authors have reported that the greater thicknesses of the coronal portion of the post could give higher core debonding load values and that the adhesion between post and composite core material could be enhanced by using an anatomically modified FRC post (Le Bell *et al.* 2004).

Conclusion

Within the limitations of this study, it can be concluded that no differences in surface morphology of three post systems were observed in spite of the fact that, in one group, FRC root canal posts were modified by grinding with a medium-grit slow-speed diamond bur. Modification of a fibre post using a diamond-coated bur maintained the surface integrity of the posts. Whether the modification of such posts influences the mechanical properties should be investigated.

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