Evaluation of the Efficacy of Two Fibre-Reinforced Post Removal Techniques

Keywords

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ABSTRACT

Objective: The aim of this in-vitro study was to compare the amount of material (post and luting agent) and root dentine removed using two methods for removal of endodontic posts. Methods: Human premolar teeth (n=20) were sectioned at the CEJ and fibre reinforced posts were cemented at a length of 10mm following root canal therapy. Teeth were randomly assigned to two study groups. The methods of removal compared were: the use of RTD re-access kit (Composipost, RTD, France, St Egreve) in a conventional hand-piece driven by an electric motor (Group A); or a long tapered diamond bur (FG Diamond grit bur, Dentsply Ltd, UK) in an air-driven high speed turbine (Group B). Using micro-CT the volume of material and root dentine removed for each sample was calculated. Results: Both the volume of material removed and the volume of root dentine removed were significantly greater when using diamond burs. ($p<0.001$). The volume of dentine removed using the diamond bur method (mean 22.64mm^3) was greater than the volume removed using the reaccess kit (mean 11.71mm^3). Significance: Use of a diamond bur to remove fibre reinforced endodontic post removal poses higher risk for root perforation compared to the reaccess kit.

INTRODUCTION

Teeth that have been endodontically treated are often found to have inadequate coronal tooth structure and a post is sometimes needed to provide sufficient retention for the core. The introduction of metal-free posts began in 1990 with the development of a prefabricated post of carbon-fiber reinforced epoxy-resin.[1] Fiber-reinforced posts are considered to offer certain advantages over metal posts, including: reduced incidence or more favorable pattern of root fracture, and improved aesthetics.[2]

The risk of infection following endodontic treatment is relatively low; however, cases of infection that require further intervention do occur. Retreatment is the preferred option in these cases as it is less stressful for the patient than surgical treatment, and this approach should eradicate any intra-canal infection which is responsible for most recurring infections.[3] In a case where root canal retreatment is indicated and the tooth was restored using intra-radicular posts, retreatment through the coronal access may not be straightforward and the post must be removed efficiently if surgical treatment is to be avoided. There are a number of ways to remove a fiber-reinforced post, such as drilling the post with burs, or through application of ultrasonic vibration.[4] Cutting the post with burs can weaken the teeth and damage tooth structure, as it is difficult to control burs inside the root canal.[5] The use of ultrasonic instruments to remove the post may be beneficial as there is little damage to the tooth

structure with this method. It works by disrupting the luting agent surrounding the post as it converts ultrasonic vibrations into mechanical energy.[5,6] However, it does have its drawbacks, as the heat generated from ultrasonic instruments can cause other major problems,[7] and it can also be very difficult and time consuming to remove a post especially if it has been bonded to the root dentin using resin luting agents.[8]

Currently, some manufacturers provide a re-access kit that they recommend for the removal of their fiber-reinforced posts. This method typically involves the sequential use of a set of three steel burs in a conventional 'slow-speed' dental hand-piece designed to cut the fiber-reinforced post from its center outwards. It is theorized that the parallel arrangement of the fibers within the post help to keep the burs centralized.

The aim of this *in-vitro* study is to compare the amount of root dentine removed using two methods (re-access kit or diamond grit bur) for removal of fibre reinforced intra-radicular posts using micro-CT analysis. The null hypothesis was that there is no difference in the amount of root dentine removed using these two methods of fibre reinforced post removal.

MATERIALS AND METHODS

SAMPLE PREPARATION

Human mandibular single rooted premolar teeth extracted for orthodontic reasons were used. The teeth were stored in purified water.

Inclusion criteria

- Human mandibular single rooted premolar teeth
- Single root canal
- Completed apex /root formation

Exclusion criteria

- Previous dental intervention prior to extraction
- Root /radicular caries
- Visible root cracks /fractures
- Abnormal root morphology
- Root length of less than 14mm

Teeth fulfilling the above criteria (n=20) were cleaned with hand curettes and de-coronated perpendicular to the root at the most coronal level of the cemento-enamel junction (CEJ) with a diamond saw (Southbay Technology Ltd, Arlington, Va, USA).

PREPARATION AND OBTURATION OF THE ROOT CANAL

The radicular canal system of each tooth was negotiated with an ISO size 15 K-Flexofile (Kerr UK Ltd, Peterborough, UK). This was used to visually calculate the working length and maintain apical patency during preparation. The working length was set at 1mm short of the anatomical apical foramen. Each tooth was prepared using a standardized crown down technique. Canal preparation was carried out using a profile nickel-titanium rotary system (Dentsply Ltd, Surrey, UK). For each tooth a profile of Ø6 taper with apical size of ISO 30 was used as the final file at the established working length in order to standardize preparation. Files were discarded after 5 uses.

Following preparation, the canal space was dried with multiple paper points and a smear of root canal sealer was placed (AH-Plus: Dentsply). Obturation was performed using Ø6 taper gutta-percha points (ProFit: quality endodontic distributors Ltd, UK) and a System B heat source (Analytic technology, Redmond WA, USA) and an endodontic plugger in a continuous wave vertical condensation technique.

PREPARATION OF THE POST SPACE AND CEMENTATION

Following endodontic obturation, gutta-percha was removed to a depth of 8mm using a size 2 Gates-Glidden bur (Dentsply) The manufacturer's post-space preparation kit (RTD DT Lightpost; St Egreve, France) was used, with sequential burs employed to create a post hole of 10mm depth to size No. 2. A new set of post preparation drills were used after every five teeth.

Following the cement manufacturer's directions, the root canal was irrigated with a 5% sodium hypochlorite solution, rinsed, and dried. The post (RTD DT Lightpost No2; St Egreve, France) was tried in ensure a passive fit and then cleaned with alcohol and dried. An "extension" tip was applied to the cement syringe and the resin cement RTD Ultimabond adhesive cement (RTD; St Egreve, France) was applied to the post and extruded directly into the root canal/post preparation. The post was immediately seated into the prepared canal and excess cement was removed with a small spoon excavator. The cement within the post space was cured for 20 seconds.

STUDY GROUPS

Samples were randomly assigned to two groups (n=10).

- Group A: Posts to be removed by a 're-access kit'.
- Group B: Posts to be removed using a high-speed diamond bur.

SCANNING

A SkyScan 1072 micro CT (Aartselaar, Belgium) was used to image the samples from groups A and B with standardized settings. Each tooth was mounted using the protruding intra-radicular post as a central locater in a custom brass jig. Prior to scanning, an individualised silicone pattern was fabricated for each tooth to allow relocation of the tooth in the same position for scanning after post removal.

REMOVAL TECHNIQUE

Post removal was done by a single operator, under a magnification of x 2.5 for all groups.

Group A

Each post in group A was removed using the RTD re-access kit (Composipost, RTD) *(Figure 1)* with the burs in a conventional hand-piece driven by an electric motor (KaVo Dental Ltd, UK) at 1500rpm. Water was used as a coolant throughout. Post removal was considered complete when a #2 RTD post-space preparation bur could be entered to a depth of 10mm. A new re-access kit was used after every three specimens as per the manufacturer's recommendations.

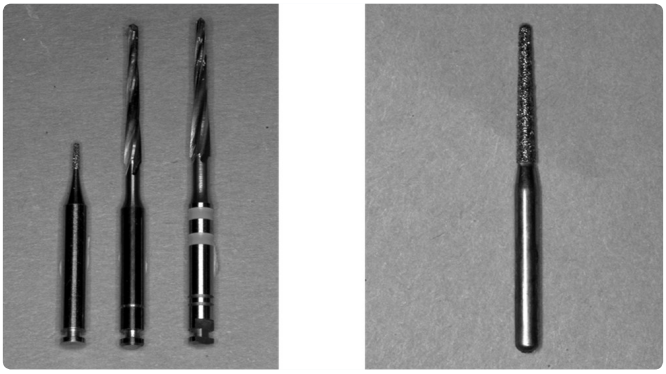

Figure 1: Burs for Post Removal

Group B

Each post in group B was removed using a compressed air-driven high-speed handpiece (KaVo) and a Hi-Di 639 10mm FG Diamond grit bur (Dentsply) *(Figure 1)* followed by final refinement with a # 2 RTD post-space preparation bur. Water was used as a coolant throughout. Post removal was considered complete when a # 2 RTD post-space preparation bur could be entered to a depth of 10mm. Each bur was discarded after 5 specimens.

RESCANNING

Each specimen from the two groups was placed in the SkyScan micro-CT using the corresponding silicone locater and jig arrangement and then rescanned with the same settings as the pre-removal scan. The SkyScan 'CT Analyser' and 'CT volume' software package was used to create a 3-dimensional reconstruct of each sample pre- and post-removal. The volume of fibre reinforced post, cement lute and dentine volume was calculated in the coronal 11mm of each sample. The pre- and post-removal reconstructs were used to calculate the volume of material (fibre and luting agent) (mm^3) and the volume of root dentine removed (mm^3) of each specimen. Examples of pre- and post-removal reconstructs are shown in Figures 2 & 3.

STATISTICAL ANALYSES

Statistical analysis was performed using a statistical software package (SPSS, Chicago, Illinois). The mean values for the volume of material removed (ExVol) and the volume of dentine removed (ΔVolD) were calculated for groups A and B and means compared with an independent t-test. Statistical significance was assumed at $p<0.05$.

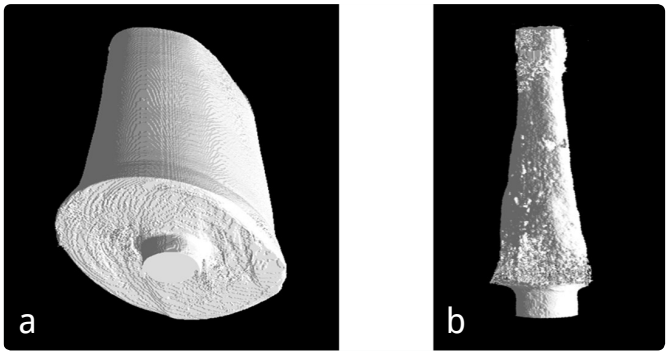

Figure 2: Reconstruct of coronal 11mm of, a) specimen b) post and luting agent pre post removal

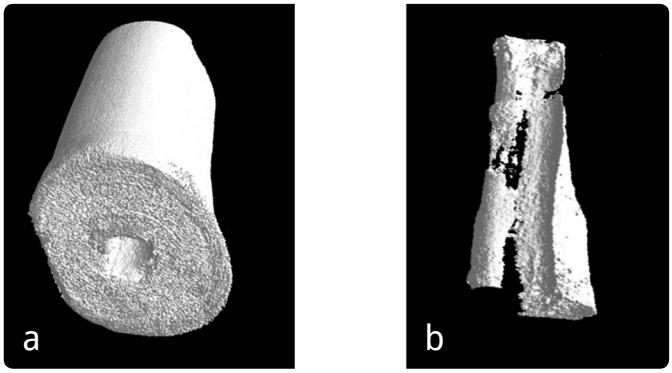

Figure 3: Reconstruct of coronal 11mm of, a) specimen b) post and luting agent after post removal

RESULTS

The volume (ExVol) of material removed for each sample is shown in Table 1. The volume (ExVol) of material removed using the diamond bur based method of removal (mean 24.85mm^3; SD 7.13) was greater than that removed using the reaccess kit (mean 10.83 mm^3; SD 4.28). The difference was statistically significant ($p<0.001$).

The volume of dentine (VolD) removed for each sample is shown in Table 2. The volume of dentine removed using the diamond bur method (mean 22.64 mm^3; SD 5.58) was greater than the volume removed using the re-access kit (mean 11.71 mm^3; SD 3.76). The difference in means was statistically significant ($p<0.001$). This data is presented in Figure 4.

DISCUSSION

While modern periodontal, endodontic and prosthetic treatments are able to give lasting protection to teeth with extensive structure loss, the actual treatment process remains a significant problem. One of the most widely used treatments for these types of teeth is the post-and-core system.[9] The materials used in post-and-core restorations must be aesthetically acceptable as full ceramic crowns are increasingly being

Table 1. Excess volume of material removed during post removal in mm^3.

Re-access Kit (Group A)	Diamond Bur (Group B)
10.80	19.31
14.42	28.73
7.88	34.77
11.20	19.46
10.83	22.06
16.36	23.81
2.21	22.60
9.21	13.44
8.86	36.24
16.47	28.09

Table 2. Volume of root dentine removed during post removal in mm^3.

Re-access Kit (Group A)	Diamond Bur (Group B)
12.60	19.73
13.10	24.72
12.92	22.41
12.63	18.39
10.51	23.97
17.09	23.81
6.13	19.15
7.49	15.84
7.69	34.61
16.89	28.44

used in the anterior area; therefore, translucent and tooth-colored materials are preferable.[10] Such materials include glass fiber reinforced posts and other non-metallic materials such as polyethylene.[9] Research suggests that the dentin-like elastic modulus of fiber posts reduces root fractures[11] and other beneficial features include aesthetics, biocompatibility, and ability to be bonded.[12,13] Studies have also clinically demonstrated the success of fiber posts.[14,15]

Sometimes during endodontic retreatment, a fiber post needs to be removed in order to access the apical section of the root canal.[4] A survey showed that most dental practitioners in the US believe that removing a post commonly leads to fractures/perforation of the tooth root.[16] However, use of appropriate techniques and tools means that posts can be removed without damage.[17] Fiber posts are now the most

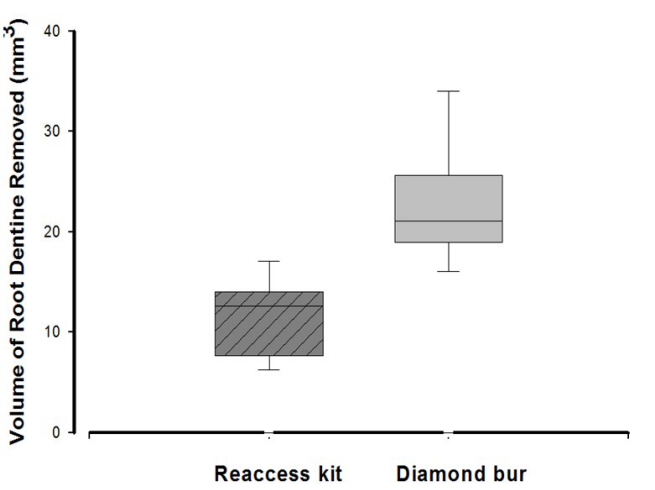

Figure 4: Volume of Root Dentine Removed During Post Removal

frequently used posts,[18] which are bonded chemically and, or micromechanically to the dentin wall. For this type of post, it is not always possible to weaken the luting agent and pull the post out.[13] Here, the post may instead be abraded along the fiber bundles.[19] Fiber post removal kits have been developed by manufacturers for this purpose, and posts can be taken out with these kits in only a few minutes. The kits usually include a starting pin pilot drill and a number of other drills to cut through the post.

The efficacy of the D.T. light fiber post removal kit versus stainless steel ultrasonic tips has been tested for the removal of fiber posts.[20] The results revealed that ultrasonic tips took longer to remove the posts than the post removal kits. Human mandibular premolar teeth were used on the basis of anatomy, convenience of size and availability. The use of a natural substrate introduces variability in canal volume, morphology, dentine structure and age changes which cannot be determined. The use of teeth, however, represents a more clinically relevant substrate than any other alternative, and although these variables are unavoidable they are reduced through the inclusion /exclusion criteria and randomisation to study group.

Micro-computerized tomography (micro-CT) is an imaging modality that is reproducible and non-invasive, which builds three-dimensional (3D) images from a series of two-dimensional (2D) scan images. Micro-CT can be used to obtain 3D images of the prepared canal anatomy, dentin thickness, volume of root canal filling material, and the dentin/post/cement interface with no damage to the tooth structure.[21-25] The 2-dimensional images produced by computerized X-ray microtomography are considered highly accurate in comparison to histological sections.[22-26] Viewing of sections obtained by the micro-CT method demonstrates good distinction of boundaries between various materials in the sample and allows observational information to be obtained regarding remaining cement /post left in-situ following post removal (*Figure 5*). No quantitative data was analysed

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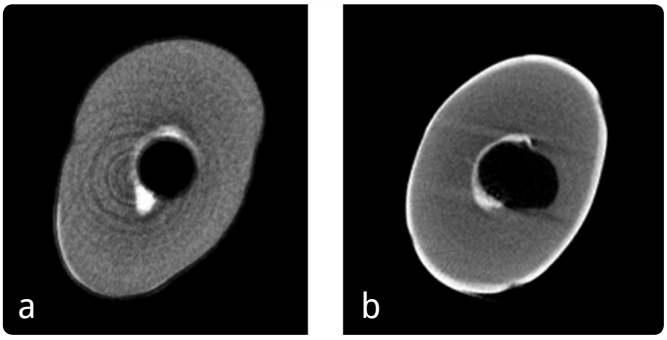

Figure 5: Micro-CT cross section following post removal, a) using re-access kit, b) using bur

regarding the amount of remaining post and lute following post removal due to the limitations in accuracy of the volume measurements for very small fractionated structures. However, observation of multiple cross-sections in both test groups would appear to show less residual post /cement left in-situ following removal with a diamond bur than with a re-access kit *(Figure 5*). This finding is in line with a previous study which reported residuals of both post and luting cement with the utilization of a reassess kit.[4] The efficacy of fibre reinforced post removal as determined by microscopic observation of the canal walls has also been studied:[27] the use of diamond burs in conjunction with ultrasonic application to remove residual post material was more efficacious than the use of a re-access kit. Both techniques, however, resulted in a significant amount of post material being left in-situ. The observation of 2-dimensional cross sections obtained by micro-CT in the present study is in agreement with this finding.

In this study, in relation to root dentine removed, the diamond bur technique proved to be much more aggressive (mean 24.85 mm^3) when compared to the reaccess kit (mean 10.83 mm^3). This would imply that the former technique results in less remaining tooth structure and may increase the likelihood of an iatrogenic root perforation in narrow roots, together with potential weakening of the remaining root.

When bonding a second post following removal of a pre-existing post, it would be appropriate to consider the internal surface of the post space with areas of residual post, cement and resin infiltrated dentinal tubules and hybrid zone.[27] This is likely to result in a reduced surface area for bonding when compared to the dentine structure in a primary post hole.[28] The easy cementation of a second post is claimed by manufacturers to be a benefit of quartz-fiber reinforced post systems; however the effect of residual post and cement debris on the tensile bond strength of a replacement fibre reinforced post (following the removal of a similar post from a tooth) is unknown, it would seem reasonable to assume a reduced surface area of fresh root canal dentine would result in a reduction in bond strength and therefore the use of a diamond bur for post removal may offer some advantages over the other method studied due to the observed reduction in remaining post and cement material.

CONCLUSIONS

Within the limitations of this study, the following conclusions may be drawn:

- The use of a manufacturer's reaccess kit, for fibre-reinforced post removal is much more efficient in terms of preserving root dentine when compared to the use of a diamond bur technique.

REFERENCES

1. Duret B., Reynaud M., Duret F. [New concept of coronoradicular reconstruction: the Composipost (1)]. *Chir Dent Fr.* 1990; **60**:131-141.
2. Goracci C., Ferrari M. Current perspectives on post systems: a literature review. *Aust Dent J.* 2011; **56**:77-83.
3. Cohen S., Burns R.C., Walton R., Torabenijad M. *Pathways of the Pulp 10 ed*: Mosby; 1998.
4. Anderson G.C., Perdigao J., Hodges J.S., Bowles W.R. Efficiency and effectiveness of fiber post removal using 3 techniques. *Quintessence Int.* 2007; **38**:663-670.
5. Johnson W.T., Leary J.M., Boyer D.B. Effect of ultrasonic vibration on post removal in extracted human premolar teeth. *J Endod.* 1996; **22**:487-488.
6. Satterthwaite J.D., Stokes A.N. Effect of ultrasonic vibration on the retention of adhesively luted intra-radicular posts. *Eur J Prosthodont Restor Dent.* 2004; **12**:101-104.
7. Satterthwaite J.D., Stokes A.N., Frankel N.T. Potential for temperature change during application of ultrasonic vibration to intra-radicular posts. *Eur J Prosthodont Restor Dent.* 2003; **11**:51-56.
8. Ettrich C.A., Labossiere P.E., Pitts D.L., Johnson J.D. An investigation of the heat induced during ultrasonic post removal. *J Endod.* 2007; **33**:1222-1226.
9. Baba N.Z., Golden G., Goodacre C.J. Nonmetallic prefabricated dowels: a review of compositions, properties, laboratory, and clinical test results. *J Prosthodont.* 2009; **18**:527-536.
10. Cormier C., Burns D., Moon P. In vitro comparison of the fracture resistance and failure mode of fiber, ceramic, and conventional post systems at various stages of restoration. *J Prosthodont.* 2001; **10**:26-36.
11. Ferrari M., Vichi A., Garcia-Godoy F. Clinical evaluation of fiber-reinforced epoxy resin posts and cast post and cores. *Am J Dent.* 2000; **13**:15B-8B.
12. Freedman G.A. Esthetic post-and-core treatment. *Dent Clin North Am.* 2001; **45**:103-116.
13. Newman M.P., Yaman P., Dennison J., Rafter M., Billy E. Fracture resistance of endodontically treated teeth restored with composite posts. *J Prosthet Dent.* 2003; **89**:360-367.
14. Naumann M., Koelpin M., Beuer F., Meyer-Lueckel H. 10-year survival evaluation for glass-fiber–supported postendodontic restoration: a prospective observational clinical study. *J Endod.* 2012; **38**:432-435.
15. Ayna B., Celenk S., Atakul F., Uysal E. Three-year clinical evaluation of endodontically treated anterior teeth restored with a polyethylene fibre-reinforced composite. *Aust Dent J.* 2009; **54**:136-140.
16. Stamos D.E., Gutmann J.L. Survey of Endodontic Retreatment Methods Used to Remove Intraradicular Posts. *J Endod.* 1993; **19**:366-369.
17. Abbott P.V. Incidence of root fractures and methods used for post removal. *Int Endod J.* 2002; **35**:63-67.

18. Ahmed S.N., Donovan T.E., Ghuman T. Survey of dentists to determine contemporary use of endodontic posts. *J Prosthet Dent.* 2017; **117**:642-645.
19. Gesi A., Magnolfi S., Goracci C., Ferrari M. Comparison of two techniques for removing fiber posts. *J Endod.* 2003; **29**:580-582.
20. Aydemir S., Arukaslan G., Saridag S., Kaya-Buyukbayram I., Ylidiran Y. Comparing Fracture Resistance and the Time Required for Two Different Fiber Post Removal Systems. *J Prosthodont.* 2018; **27**:771-774.
21. Swain M.V., Xue J. State of the art of Micro-CT applications in dental research. *Int J Oral Sci.* 2009; **1**:177-188.
22. Paqué F., Barbakow F., Peters O.A.J.I.E.J. Root canal preparation with Endo-Eze AET: changes in root canal shape assessed by micro-computed tomography. *Int Endod J.* 2005; **38**:456-464.
23. Dowker S.E., Davis G.R., Elliott J.C. X-ray microtomography: nondestructive three-dimensional imaging for in vitro endodontic studies. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 1997; **83**:510-516.
24. Peters O.A., Laib A., Gohring T.N., Barbakow F. Changes in root canal geometry after preparation assessed by high-resolution computed tomography. *J Endod.* 2001; **27**:1-6.
25. Arukaslan G., Aydemir S. Comparison of the efficacies of two different fiber post-removal systems: A micro-computed tomography study. *Microsc Res Tech.* 2019; **82**:394-401.
26. Dowker S.E.P., Davis G.R., Elliott J.C. X-ray microtomography - Nondestructive three-dimensional imaging for in vitro endodontic studies. *Oral Surg Oral Med O.* 1997; **83**:510-516.
27. Lindemann M., Yaman P., Dennison J.B., Herrero A.A. Comparison of the efficiency and effectiveness of various techniques for removal of fiber posts. *J Endod.* 2005; **31**:520-522.
28. Serafino C., Gallina G., Cumbo E., Ferrari M. Surface debris of canal walls after post space preparation in endodontically treated teeth: a scanning electron microscopic study. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 2004; **97**:3