IN BRIEF

- Most published literature on fibre-based posts take the form of laboratory analyses.
- Evidence for carbon-fibre posts far exceeds that for quartz-fibre posts and further investigation of these posts is necessary before these can be recommended for routine use.
- Laboratory evidence was contradictory and may not be used to reliably inform practice.
- Few clinical studies have been carried out though these have suggested fibre-based posts may be clinically appropriate for restoration of the endodontically treated tooth.
- Controlled prospective clinical trials evaluating fibre-based posts should be undertaken before adoption in clinical practice.

Fibre-based post systems: a review

G. Bateman,[1] D. N. J. Ricketts[2] and W. P. Saunders[3]

Objectives This article presents a review of published literature examining fibre-based endodontic post systems.
Data sources A MEDLINE search was carried out for any articles in dental journals pertaining to fibre-based post systems. Wherever possible articles cited were obtained from the journals and where this was not possible abstracts were obtained. Where no abstract was available the article was not considered for evaluation.
Data extraction Articles were reviewed by a single observer and subject to meeting inclusion criteria were included in the review. Fifty-nine articles were considered suitable for inclusion.
Data synthesis Articles were divided into categories and a subjective description of the articles was made.
Conclusions Review indicated that (1) most published literature on fibre-based posts took the form of laboratory analyses; (2) evidence for carbon-fibre posts far exceeds that for quartz-fibre posts; (3) laboratory evidence was contradictory and could not be used to inform practice reliably; (4) few clinical studies have been carried out though these have suggested fibre based posts may be clinically appropriate for restoration of the endodontically treated tooth; and (5) controlled prospective clinical trials evaluating fibre-based posts should be undertaken to inform use for clinical practice.

Teeth that have been endodontically treated often have little coronal tooth tissue remaining and as such require a post to retain the core and restoration. Traditionally these posts have been cast or machined from metal and it is acknowledged that such posts weaken roots and lead to root fracture.[1] In fact, prosthetic failure has been cited as the most common cause of failure in endodontically treated teeth.[2] Whilst placement of posts may contribute to this finding, cross-sectional surveys of failed posts[3,4] have shown that most failures are because of post decementation. Included as other causes for post crown failure are caries and post fracture. Of greatest concern clinically is irreversible failure with root fracture necessitating extraction of the tooth.

[1,2]Lecturer in Restorative Dentistry, [3]Professor of Endodontology, Department of Comprehensive Restorative Care, Dundee Dental Hospital and School, Park Place, Dundee DD1 4HN
Correspondence to: G. Bateman, Department of Comprehensive Restorative Care, Dundee Dental Hospital and School, Park Place, Dundee DD1 4HN
E-mail: gjfbateman@hotmail.com

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In 1990 Duret *et al.*[5] described a non-metallic material for the fabrication of posts based on the carbon-fibre reinforcement principle. Laboratory-based studies have shown that these posts have a high tensile strength[6] and modulus of elasticity, similar to dentine.[7] Previously, rigid metal posts resisted lateral forces without distortion and this resulted in stress transfer to the less rigid dentine causing potential root cracking and fracture. It is thought that fibre-posts flex under load and as a result distribute stresses between the post and the dentine. Currently available fibre-based posts are essentially composite materials. They are composed of fibres of carbon or silica surrounded by a matrix of polymer resin, usually an epoxy resin. A wide variety of posts are available and include parallel-sided, tapered, smooth and serrated forms. Carbon-fibre posts are black in colour and do not lend themselves to aesthetic restorations with all-ceramic units. This led to the introduction of the silica-fibre posts which are translucent and more tooth coloured. These posts are also called glass-fibre and quartz-fibre. It has been suggested by manufacturers that these posts retain similar physical properties to carbon-fibre posts though there is little in the way of published evidence to demonstrate this. Stewardson provides a thorough review of the fibre-based post systems available and their properties.[8]

Although there is a body of published evidence on fibre-based posts there is little consensus relating to their physical and clinical properties and techniques. It is the purpose of this review to examine the available peer-reviewed literature in a systematic and reproducible manner and to present a summary of factors which may influence the choice of these posts to restore endodontically treated teeth.

METHODS

The initial review began with a MEDLINE search for citations indexed from January 1966 to July 2002. The search was for citations which contained the following principal key terms: post/posts or dowel/dowels together with either fiber, fibre, quartz, carbon, silica or glass fibre/fiber. Composipost and C-post/posts were included as a separate search as relevant citations were found under these terms that were not previously shown. The search was limited to dental journals and all citations were collated and duplicates were discarded. Wherever possible the full texts of papers were obtained from the journals. Where it was not possible to obtain a particular journal, the abstracts, where available electronically were examined. Therefore the inclusion criteria for articles were: (1) Any articles related to fibre-based prefabricated endodontic posts; (2) Only papers in refereed dental journals; (3) All papers in a foreign language where an abstract in English was available. As there was little published material on fibre-based post systems all papers available were selected for inclusion in the review. Literature not published in widely available, refereed journals or in a foreign language was not examined though wherever possible an abstract was sought for these. The grey literature, that is information not reported in the periodic scientific literature, was rejected. References in papers were checked and cross-matched with those from the original MEDLINE search. Where additional references were found which met the inclusion criteria, these were included in the review.

RESULTS

The original search strategy resulted in 264 articles. The total number of papers which met the inclusion criteria for the review was 59. Of these, 41 were *in vitro* studies, 7 were clinical studies and 11 were case reports and review articles.

The majority of the literature took the form of investigations conducted *in vitro*.[5,6,9–40,42–46] These studies examined a number of areas such as the physical properties of the posts and post/root relationship,[6,7,9,12–14,20,22,23,26–29,31–33,35,37,38,42] retention testing,[11,15,19,22,30,32–34,36,43,44] scanning electron microscopy of the post/root interface,[14,16,17,22,38,40,46,47] microleakage,[10,24] and corrosion of metals with fibre-posts.[18] Other papers examined thermal stress,[41] spectrophotometric analysis,[39] cytotoxic properties of fibre-based posts[38] and radiopacity.[26,45]

A number of clinical studies have been published looking at fibre-based posts. Of these some were retroprospective analyses of the clinical success of fibre-based posts[48–50] while others were prospective studies.[42,51–53]

Table 1 Studies investigating *in vitro* fracture resistance of post-types.

Reference	Type of fibre-based post	Metal post types compared with	Number of posts investigated: Fibre	Number of posts investigated: Metal	Other Experimental groups	Force to post fracture (average): Fibre	Force to post fracture (average): Metal	Post performance (fracture resistance)
27	Carbon-fibre (CF) (Composipost™)	Matched cast post/core	22	22	No	103.7 kg (SD = 53.1)	202.7 kg (SD = 125)	Fibre < metal
37	Composipost™	Cast post/core Preformed stainless steel	10	2x10	10 x teeth with no post	8.89 MNm^{-2} (SD = 2.40)	SS: 14.18 MNm^{-2} (SD = 3.49) Cast: 15.25 MNm^{-2} (SD = 4.07)	Fibre < metal < no post
9	Quartz-fibre(QF) Glass-fibre(GF)	Titanium	2 x10	10	10 x Zirconia (ZR) posts	QF 91.2kg GF 75.9 kg	66.95 kg	QF > other groups, GF = ZR
20	Composipost™	Cast posts+ titanium Paraposts™	14	10+11	No	Not applicable – cyclic loading test		Fibre> titanium > cast post
31	Composipost™	Palladium (Pd) and non-palladium preformed posts	10	10x Pd 3x10 Non- Pd	10x Zirconia 10x Alumina 10x Metal post + ceramic core. 10x Control-no post	312.5 +/- 58.8N	Pd posts 265.9N Non Pd 242.3-300.4N (control group – 228.8+/- 35.7N)	Fibre> Palladium = Non-Palladium
6	Experimental carbon-fibre post. (10 composite core, 10 gold core)	Preformed precious post preformed stainless steel (SS)	20	20	No	Gold core 15.75 MNm^{-2} (SD = 2.08) Comp core 14.42 MNm^{-2} (SD = 3.0)	Cast: 16.24 MNm^{-2} (SD = 2.6) SS: 13.00 MNm^{-2} (SD = 2.53)	Cast post > SS Fibre + cast core > SS
13	Composipost™	Tapered SS post Parallel SS post.	20 - 10 in access, 10 after decoronation	10x tapered 10x parallel	10x crown prep, 10 x prep + GP in access 10 x composite in access	CF in access 163.8 kg SD 37.5. Decoronate CF 107.4 kg SD = 26.3	Tapered post 111.6 kg SD 19 Parallel 107.8 kg SD = 17.5	Decoronated teeth fibre post= tapered SS = parallel SS.
29	Composipost™	Cast gold post/core	10	10	Other non-post restorations.	Not available	Not available	Fibre posts = Cast gold posts
35	Composipost™	Cast post /core SS post	10	1x10 1x10	No	307+/-33N	Cast post 374+/-104N SS 305 +/- 47N	Cast post > fibre post = SS post

Other published literature included case reports[54,55] non-systematic reviews and practice guidelines.[7,55-58,61-64]

Investigations conducted *in vitro*

Rigidity and flexural strength

Post distortion and fracture have been cited in previous studies as a cause of failure of the post-restored tooth.[3,60] This can lead to loss of the restoration or at worst irrevocable root fracture. Many studies on fibre-based posts concentrate on their physical properties under load. Some workers suggest that a more rigid system is advantageous as a smaller diameter of post may be used therefore allowing a greater conservation of tooth tissue during preparation.[35] Others have suggested that a Young's modulus approaching that of dentine is more desirable, as stress transmitted to the root on loading of the post will decrease, thus reducing the risk of root fracture.[20] Results of three-point bending tests of fibre-based posts compared with metal posts have shown that fibre-based posts are less rigid[12,32] though greater rigidity for carbon-fibre posts has been suggested by others.[33,38] Certain factors can alter their physical properties. The flexural strength is decreased , when immersed in water[26,38] and thermocycled.[15,44] The authors suggest that this may be an important factor in failure of the restoration clinically. Surface modification of carbon-fibre posts is thought to alter the physical properties and it has been shown that serrated carbon-fibre posts are less rigid than matched smooth-sided posts. However the rigidity of the serrated posts is similar to stainless-steel posts.[22]

Fracture resistance

Fracture resistance testing of post restored teeth and root analogues[31] gives a clearer idea of how these posts might perform clinically. Numerous studies exist, with conflicting conclusions. The fracture resistance to impact of otherwise sound teeth restored with stainless steel posts, carbon-fibre posts and access cavity restoration only was examined.[28] This study concluded that there was no advantage from the point of view of fracture mechanics in restoring these teeth with either post type. This is in agreement with other workers.[13] Fracture mechanics of the post-restored root with increasing loads has been the subject of several laboratory-based trials. These studies appear to have contradictory conclusions and are summarised in Table 1. Cormier *et al.*[12] examined fracture resistance of teeth at four stages of simulated clinical treatment – post only, post in root, post and core in root and post core and crown combination. This study showed that fracture resistance and mode of failure changes based on the stage of restoration of the tooth. Thus a crown restoring a post and core is more fracture-resistant than a post or post and core combination alone. Mode of failure with a crown in place however, results in an increased incidence of unfavourable root fracture. This suggests that *in vitro* fracture testing of post-restored roots where a crown is placed may be more relevant clinically. It has been suggested that the failure with fibre-based posts is less likely to include irreparable root fracture than with metal posts.[6,9,12,13,20,23,27] Zirconium posts have been compared with fibre-based posts and have been concluded to be a potential cause of failure by root fracture.[23] The findings of the laboratory studies on fracture resistance should be interpreted with some caution. Numbers of teeth in these studies were low and results would appear to be contradictory.

Core retention

Retention testing of fibre-posts is an area that has received some attention in the literature both with respect to post retention in the canal and core retention on the post. Purton and Payne[33] showed in tensile testing that composite cores had better retention to stainless steel posts than carbon-fibre posts. These workers however looked at smooth carbon-fibre posts and serrated stainless steel posts and it has been shown that core retention is similar where the carbon-fibre post was serrated.[22] This might suggest that mechanical retention of the core may be more important than chemical bonding between the components of the post and core. Surface treatment of smooth carbon-fibre posts with aluminium oxide blasting and grooving with diamond burs has been shown to make core retention comparable with that of the serrated version.[34]

Post retention in the root

Within the prepared post space, cemented stainless steel posts have been shown to be more retentive than carbon-fibre posts[11,32] when cemented with either resin or zinc phosphate cement. Other workers have however, shown no difference in retention[15,22,44] where posts were cemented with a resin cement. Significantly increased retention for carbon-fibre posts of a larger diameter has been shown by another group.[43] When failure occurs, it has been shown that this is always at the cement/post junction[36] and that superior retention exists where the posts have a mechanically retentive design. Interestingly, compared with metal posts, greater failure of carbon-fibre posts on loading because of root fracture has been demonstrated.[43] The authors related this to lack of stiffness of the carbon-fibre posts. In pullout tests, Drummond *et al.*[44] demonstrated that thermal and cyclic loading, and abrasion of the post prior to cementation with alumina may cause a significant decrease in bond strength and post strength itself. A bond strength investigation of different cements to different post materials[30] has shown Panavia[21] (J. Morita, Ca, USA) to be significantly better than other cement types. These workers showed that adhesive resins had higher bond strengths to stainless steel and titanium posts than carbon-fibre posts.

Scanning electron microscopy (SEM) studies

Initial investigations focused on the posts themselves. Torbjorner *et al.*[38] examined carbon-fibre posts using SEM and concluded that failures occurred in the fibre-matrix interface and as microcracks within the matrix. These effects were noticed after water storage and after thermocycling but more obviously after a combination of both. Examination of post serrations by scanning electron microscopy[22] showed a post surface covered in a smear of debris and carbon fibres and at the serration site the fibres appeared to be cut. The authors suggest that the rigidity of these posts was inferior to a post that had been moulded rather than machined.

The relationships between the core material and dentine at the root face, and between the post, the luting cement and dentine within the root space after a non-destructive fatigue test were examined in one study.[14] The micromechanical and chemical adhesion to the differing post materials was shown to be satisfactory. Poor adhesion was shown between core and dentine in the carbon-fibre post group. The authors related this to lack of a hydrophilic primer in the original cementation kit at that time. Though a less effective adhesive was used, the luting-cement/dentine interface did not show higher proportions of debonding in the carbon-fibre post group when compared with other post groups. This might confirm the favourable influence of post elasticity.

Ferrari and Mannocci[46] presented a case report of a tooth scheduled for extraction where a carbon-fibre post was placed with a one-bottle adhesive system used for dentine preparation prior to luting. SEM investigation of the harvested tooth showed a hybrid layer between the resin and root dentine, resin tags and adhesive lateral branches in the root dentine. Thus dentine bonding to the prepared post space was possible and is essentially micromechanical in nature. This has been confirmed by other studies[16,17,40,47] some of which have shown that the use of a microbrush is superior to a small plastic brush in creating a predictable bonding surface along the length of the root canal.[17,40] Preparations in these studies were gently air-dried after etching and rinsing. Some authors used paper points to remove excess moisture in the canal and others used paper-points to blot pooled primer in the post space. Whilst canal preparation is clearly important prior to bonding, there are no definitive guidelines on how this should be carried out.

Microleakage
There was little in the way of published evidence which met the inclusion criteria examining microleakage of fibre-based post systems. Bachicha *et al.*[10] compared a stainless steel and a carbon-fibre post cemented with different techniques using a quantitative fluid filtration model. The authors showed no significant difference between the two post types and that both posts when cemented with dentine bonded resin cements exhibited less microleakage than when cemented with glass ionomer or zinc phosphate. This study measured microleakage after 24 hours and did not assess the effect of wet storage, thermal or mechanical loading. Mannocci *et al.* investigated teeth restored with carbon-fibre posts and composite cores using confocal microscopy and dye penetration.[24] This investigation showed that a three-step dental adhesive resulted in a better marginal seal than that obtained with two self-etching primers. The authors also demonstrated that the use of a zinc oxide-eugenol based endodontic sealer had no detrimental effect on the marginal seal of carbon-fibre post/composite resin core restorations. The resin based cement groups in this investigation leaked significantly less than a control group of carbon-fibre posts cemented with zinc phosphate.

Other in vitro *investigations*
Fovet *et al.*[18] have shown in galvanic coupling tests between carbon-fibre posts and metals that a corrosion reaction can be set up. This study examined electrochemical behaviour of posts coupled with gold, NiCr and amalgams in an artificial saliva medium. Galvanic activity was shown in contact with amalgams and NiCr alloy though this was unlikely with precious alloy. The authors suggest that this may have clinical relevance and that amalgam should not be used in conjunction with posts. It is also suggested that the post head should be buried in the core restorative material.

A study employing finite element analysis[41] has suggested that fibre-posts produce greater stresses within the root canal when exposed to thermal change than metal post systems. The paper argues that the high thermal conductivity of metal posts leads to a reduced temperature gradient throughout the restored system whereas a reduced heat flow into dentine with non-metal posts may cause a concentration of thermal stresses. The authors suggest that this may lead to cement failure and recommend the use of a metal post and core.

Cytotoxicity testing by an agar overlay method[38] has shown carbon-fibre posts to be free from obvious cytotoxicity. The authors however caution against extrapolation of the *in vitro* results to the *in vivo* situation as correlation with this testing regimen is often poor.

Spectrophotometric analysis has shown that dark coloured opaque posts were fully masked when covered with an all ceramic restoration where the ceramic layer exceeded 2 mm.[39] This paper suggested the use of all-ceramic crowns were contraindicated where less than 1 mm of ceramic thickness could be provided.

Two studies were available examining the radiopacity of fibre-posts. Mannocci *et al.*[26] briefly examined this in a study examining three-point bending of fibre based posts. Five post types were examined: Composipost (RTD, St. Egreve, France), Aestheti-Plus quartz fibre posts (RTD, St. Egreve, France), Carbotech carbon-fibre posts (Ganges, France), Light posts (RTD, St. Egreve, France), and Snowposts (Carbotech, Ganges, France). Twenty-one posts for each post type were examined radiographically. Only Composiposts and Snowposts were found to be uniformly radiopaque. A later study[45] examined the radiopacity of selected posts both outside the tooth and inside extracted canine teeth before and after cementation with Panavia.[21] One titanium post was included as a reference. Standard radiographs were exposed and density of image was evaluated together with a reference aluminium step-wedge. Two randomly selected radiographs for each post group were ranked for radiodensity and clinical acceptability by 20 dental practitioners. The titanium post, Snowlight (Carbotech, Ganges, France) and Snowpost were found to be better than acceptable and FibreKor (Jeneric/Pentron, USA), a quartz-fibre post, was found to be acceptable. Other post groups were found to be radiolucent or have clinically unacceptable radiodensity.

***In vivo* studies**
Currently there are few published clinical studies of fibre-based post systems. This search of the literature revealed only four prospective clinical trials and three retrospective clinical studies. The duration of the studies vary from 12 to 28 months for the prospective trials and 32 months to 4 years for the retrospective studies. It appears that no prospective randomised controlled clinical trials exist evaluating fibre-based post systems.

Prospective studies
Glazer *et al.*[51] published results for a study in which results for 52 teeth in 42 patients were analysed. Of these, 37 were maxillary teeth and 15 were mandibular. This included incisors, canines and premolars. Each tooth was restored with carbon-fibre posts. These were either a Composipost — 38 posts or a University of Montreal Endopost (Biodent, Quebec, QC) — 14 posts. These were cemented with a resin luting cement — C&B Metabond (Parkell, Farmingdale, NY). A resin core was placed followed by a full coverage restoration. These teeth were followed up for 6.7 to 45.4 months (average 28 months, standard deviation 10.7). The overall failure rate was 7.7% (4 teeth); 2 teeth failed because of periapical pathology and 2 were mechanical failures of the restoration. The only statistically significant finding was that posts in lower premolars were at a higher risk of failure (2 teeth).

In this study selection criteria for patients were unclear. The author used two different post types but it was unclear as to how these were allocated amongst the groups. There was no control group with placement of a metal post included in the study. Follow up was carried out by one operator but success/failure in six of the cases was determined by their referring dentist where the patient was unable to return for review. The author acknowledged this study had a low sample size, the length of follow up was short and the carbon-fibre post insertion phase of the study took place over a long period (3 years).

A more recent study examined the use of fibre-posts in restoring primary incisors.[42] Root canal therapy was carried out in these teeth and short (2–3 mm) quartz-fibre posts (FiberKor) were bonded into the root canals of these teeth. This was followed by placement of a direct composite crown. A total of thirty teeth in 12 patients was analysed. These teeth were followed up for a period of 1 year. The failure rate at this stage was 6.6%. The author attributes this to failure of pulpal therapy and not to the post technique used. In this study again selection criteria were not clear, no control group was used, numbers were low and follow up was short.

In addition to these two published papers, two abstracts were obtained for papers in foreign languages. An abstract was obtained for a paper in Hungarian[52] which described a clinical trial of carbon-fibre posts (Composipost). Fifty-five patients were treated though it was unclear how many posts were placed. After 24 months follow up, no failure was recorded. Numbers were low and it was not possible to ascertain from the abstract how patients were selected, the clinical techniques used or whether a control group was used.

The second abstract was obtained for a study from the University of Sassari, Italy.[53] Here 46 subjects were selected and 60 teeth were restored with Tech 2000 carbon-fibre posts. Almost half of the selected teeth were single rooted. The success rate was 98.4% though it was not clear from the abstract how long the follow up period was and whether or not a control group was used. These abstracts do not provide enough detail to be used to reliably inform clinical practice.

Retrospective studies

Whilst well-constructed randomised controlled trials are regarded as best evidence, a number of retrospective studies have been reported and add to our knowledge. Fredrikkson *et al.*[50] reported a retrospective study of 236 patients. In this group, 236 teeth were restored with carbon-fibre posts by seven randomly selected Swedish dental practitioners during a 1-year period. The duration of service time for these posts varied from 27 to 41 months with a mean restoration time of 32 months. One hundred and forty-six patients consented to clinical evaluation and data for the remaining 90 patients was obtained from case records. Of the patients examined clinically, the contralateral tooth was used as a control and where this was not possible a tooth similar in anatomy and jaw position to the post-restored tooth was used. Clinical examinations were carried out independently by two calibrated observers though it was not possible to blind the examiners. Of the 236 teeth treated, 5 of these were extracted within 2–6 months because of severe periodontitis in two teeth, periapical destruction around one root and two root fractures. No posts were dislodged and there were no root or post fractures observed clinically or on radiographs in the remaining 231 teeth. The estimated 95% confidence interval for the percentage of success in the population was 96-99% over the period of the study.

Ferrari *et al.*[48] reported a 4-year retrospective study of 200 patients each with a single endodontically treated tooth which required a post and core restoration. Teeth included in the experimental groups were both anteriors and posteriors in the mandible and maxilla. The patients were randomly and equally divided into two experimental groups. One group received a carbon-fibre post (Composipost) cemented according to manufacturers' instructions, the other a cast post and core cemented with a traditional technique. Although this evaluation has been described by the authors as retrospective, it is not clear why the patients were randomly divided at the beginning of the study. The patients were recalled after 6 months, 1, 2 and 4 years when clinical and radiographic information was recorded. Ninety-five per cent of the teeth restored with carbon-fibre posts showed clinical success. Over the 4-year period, 3% of this sample were lost to follow-up and 2% showed endodontic failure. The success of the cast post and core group was significantly inferior; only 84% were deemed to be a success. Two per cent of this sample were lost to follow up, 9% showed root fracture, 2% dislodgement of the crown and 3% endodontic failure.

In a separate study, the clinical performance of a carbon-fibre post: Composipost (840) and newer quartz-fibre based post systems: AesthetiPosts (215) and Aestheti Plus Posts (249) have been evaluated after 1 to 6 years of clinical service.[49] A total of 1,314 posts, placed by three operators, were included in the study where four combinations of bonding/luting materials had been used. The patients were recalled every 6 months and clinical and radiographic evaluations were completed. The duration in service of the Composipost group varied from 18 to 68 months (mean = 46). The AesthetiPosts were observed for a period ranging between 12 to 18 months (mean = 14) and AesthetiPlus Posts between 12 to 16 months (mean = 13). Results showed only a 3.2% failure rate and no statistically significant differences were found between the groups. The authors state that failure was related to debonding during removal of temporary restorations (25 posts) and periapical lesions at the radiographic examination (16 teeth).

These studies lend weight to the suggestion that the similarity of the modulus of elasticity of the posts to dentine means that the teeth restored with these are at less risk of irreversible failure because of root fracture. These results also suggest that fibre-based posts can be used for restoring endodontically treated teeth; however, the authors suggest that caution and prospective clinical trials are necessary before final conclusions on the clinical suitability of these posts can be determined.

Other literature

A number of case reports have been published detailing clinical techniques in restoring teeth with fibre-based posts.[54,55] Although many have been published, a number lack an abstract or are not in widely available journals and have therefore been excluded from this review. Boudrias *et al.*[54] presented a case report describing a new quartz-fibre endodontic post and explored the rationale behind its development and demonstrated the associated clinical technique. These authors recommend the use of a double-tapered post to more closely conform to the tapered anatomy of the root canal. This is an interesting move from the traditional parallel-sided post design and as yet remains untested in laboratory and clinical trials.

There have been a number of non-systematic reviews published [8,58,59,61–64] though again there were many unsuitable for inclusion because these papers were not in widely-available journals or lacked an abstract. To date, the MEDLINE search has not revealed any systematic reviews relating to fibre-based post systems.

Post removal

Post fracture is a recognised complication of metal-based post systems and when this occurs the remaining post segment may be removed with the aid of ultrasonic energised instruments.[65] It is sometimes necessary to remove posts where endodontic failure occurs to allow retreatment. deRijk[56] suggested clinical guidelines for the removal of fibre-posts. The author described simple steps in this technique which he felt were predictable. Removal of these posts is accomplished by progressive drilling through the middle of the post with specially designed reamers. The author suggests the use of new reamers for each case. This is an area that has not been explored thoroughly and clearly requires further research.

DISCUSSION

This paper attempts to systematically examine the available literature on fibre-based endodontic post systems within strict inclusion criteria. The purpose of the inclusion criteria was to attempt to limit papers for review to those which appeared in widely available peer-reviewed journals and contained an abstract. This review was not intended to be exhaustive and the authors acknowledge that attempts were not made to examine unpublished data, grey literature and data published in a foreign language. MEDLINE is perhaps one of the most commonly used databases for searching the dental literature. The references in the selected papers were search and cross-matched with the results of the MEDLINE search. No additional papers were found which met the inclusion criteria therefore no other databases were searched as it was felt that little additional information would be retrieved. We do however believe that, within the limitations, this review presents a good insight into the evidence available. The authors were unaware of any published systematic reviews in this area.

The majority of the literature described laboratory investigations whereas relatively few clinical studies have been carried out. This is presumably because of the greater degree of difficulty in conducting *in vivo* standardized studies. Most laboratory investigations concentrate on the physical properties of fibre-based posts examining three-point bending values, flexural strength and retention of both the post in the canal and core materials to the post. These *in vitro* studies have produced conflicting results and may not inform clinical practice reliably. Scanning electron microscopy studies have shown storage in water and thermocycling have a detrimental effect on post integrity. Bonding to post and root dentine has also been investigated by SEM and the use of a tapered microbrush has been suggested to improve the bond in the apical portion of the post space. Only two microleakage studies were included in the review.[10,24] These concluded that there was no significant difference between quartz-fibre and metal post types and that resin-based cements were superior to zinc phosphate and glass-ionomer. This is an area where the authors feel that further research is necessary.

It would appear that in general practice in the UK, quartz-fibre posts are more widely used than carbon-fibre posts. The majority of published evidence however, relates to carbon-fibre posts and far exceeds that for quartz-fibre posts. It will clearly be important to investigate quartz-fibre posts more thoroughly before these can be recommended for routine use.

The few clinical trials that have been published[42,48–52] suggest, at least in the short term, reasonable success for fibre-based post restorations. The authors feel however that before these posts are adopted fully in the clinical practice, high quality randomised controlled prospective clinical trials are necessary, investigating the success of fibre-based post restorations and newer materials such as quartz-fibre posts.

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