Failure Mechanisms of Fibre Posts: A Literature Review

ABSTRACT

Aim: to review the available evidence for the causes of failure of fibre posts.

Materials and method: A search of MEDLINE was conducted to retrieve available data on fibre posts used for restoration of endodontically treated teeth since 1980. The Cochrane Library was also separately searched for systematic reviews. Additionally, references of the retrieved articles were also hand searched for further relevant papers. All the selected papers were then critically appraised subject to meeting inclusion criteria.

Results: Nineteen prospective clinical trials were included after critical appraisal of the papers. Causes of failure of fibre posts were identified as follows: adhesive failure, root fracture, post fracture, endodontic failure, secondary caries and periodontal complications. Risk factors for each of the failures were investigated and evidence-based recommendations for minimising these complications are discussed.

Conclusion: Although laboratory studies showed favourable mechanical and physical properties of fibre posts, clinically, there has been a wide range of failures mechanisms are reported in the literature. Adhesive failure was reported in 16 of the 19 trials, making it the most frequent cause of failure. The available evidence does not indicate a difference in short-term survival probability between metal or fibre posts. A number of risk factors, which affect the longevity of fibre posts, were identified and discussed. Since there is considerable heterogeneity in study designs and reported survival rates of included studies, longer-term well-designed standardised clinical trails are required.

Keywords

Fibre Posts
Glass-Fibre Posts
Endodontically Treated Teeth
Failure Mechanism
Complications

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Received: 29.09.14
Accepted: 05.07.15

doi: 10.1922/EJPRD_1409Barfeie13

INTRODUCTION

Using a post to restore a tooth with part or most of the natural crown missing is not a recent dental treatment. Generally, an intra-radicular post is placed into an endodontically treated tooth with excessive loss of crown structure to retain the coronal restoration, more specifically the core.[1] According to the guideline suggested by Christensen,[2] in order to predictably restore a tooth with more than 50% coronal structure missing, a post is required to retain the core. Cast posts and metal prefabricated posts have been utilised over the past 250 years.[3] Non-metal posts as an alternative treatment have been used since the mid-1980s.[4]

In 1988 two French dentists, Duret and Renaud, were first to introduce the carbon fibre post or carbon fibre-reinforced epoxy resin post. It was in the early 1990s when carbon fibre posts were introduced in Europe. Contemporary fibre posts, which are also known as fibre-reinforced composite (FRC) posts are made of carbon or glass fibre, embedded in a matrix of epoxy or methylacrylate resin. Fibres are oriented along the long axis of the post, their diameter ranges from 6 to 15 μm and in a transverse section of the post, they occupy approximately 35% to 50% of the area.[5] The surface of the post has a roughness of 5-10 μm to enhance mechanical

adhesion of autopolymerising luting materials, and the post appears to be biocompatible based on cytotoxicity tests.[6]

Considerable controversy still exists with respect to the optimal selection of post materials. Several authors support the view that a post system with an elastic modulus of close similarity to that of dentine[7] will reduce the risk of catastrophic root fracture as the functional stresses are more evenly distributed along the root canal[6,8,9] while others advocate that a root canal post of high modulus should be preferred.[10] In contrast to metallic posts, fibre posts are biocompatible and resistant to corrosion.[11] However it has been documented that they are susceptible to moisture degradation.[6] Recent enhancements in aesthetic dentistry and ceramics has led to an increasing demand in non-metal alternatives.[12]

Another advantage of using fibre posts is reportedly easier post removal from the root canal if endodontic retreatment is necessitated, however opinions of Endodontic specialists vary.[13] One of the main concerns with regards to fibre post placement is the flexion of the post in anterior and lateral excursions resulting in core debond and failure of the fibre post and core. Several other complications are also reported in the literature. Therefore, the aim of this article is to review the available evidence on the failure of fibre posts that could be minimised in order to optimise clinical outcomes.

MATERIALS AND METHOD

A systematic approach was undertaken to search the MEDLINE database to retrieve prospective clinical trials on fibre posts used for the restoration of endodontically treated teeth since 1980 when fibre posts were introduced for restorative purposes. The Cochrane Library was also separately searched for systematic reviews. The keywords "fibre posts OR fiber posts", "endodontically treated teeth OR endodontically treated tooth OR root filled teeth OR root filled tooth", "post and core", "glass fibre post OR glass fiber post", "parapost" and "fibre reinforced composite OR "FRC" AND "failure" was used to discover clinical and laboratory studies. Additionally, references of the retrieved articles were also hand searched for further relevant papers. The search was limited to dental journals. Wherever possible the full text was obtained otherwise the abstracts were electronically examined.

The following criteria were considered for inclusion criteria:

(1) Prospective clinical trials related to fibre posts; (2) only papers published in refereed dental journals; (3) papers published in English language

EXCLUSION CRITERIA

1) Laboratory, retrospective and literature review papers were excluded; 2) papers that did not clearly report the causes of failure of fibre posts; 3) papers with follow-up period of less than 1 year 4) papers that evaluated non-fibre posts 5) papers with unclear measurements and statistical analysis of fibre post failure

DATA EXTRACTION:

One clinician (A B) extracted the data. The following information was recorded for each study: 1) type of post assessed; 2) study design; 3) amount of remaining residual coronal tooth structure; 4) core material used with the fibre post 5) fibre post cementation material 6) type of final restoration 7) overall success rate

Ferrari, Vichi[14] categorises failures as 'relative' or 'absolute' failures. 'Absolute' failure is considered when root fracture resulted in tooth extraction. Any other failure, which did not lead to extraction of the tooth, regarded as 'relative' failure. Zicari, Van Meerbeek[15] defines 'success' as the outcome in the absence of absolute and relative failures, while survival as the outcome in the absence of absolute failure. These definitions were adopted for failure of fibre posts in this review.

RESULTS

Table 1 and 2 demonstrates the list of included studies. Table 1 contains demographic information of each study. Table 2 includes the causes of failure of each study.

CAUSES OF FAILURE

The following complications were reported in the included literature: adhesive failure, post fracture, root fracture, endodontic complications, dislodgment of the post, failure of the core and crown and secondary caries.

Adhesive failure

Adhesive failure or debonding appeared to be the most frequent cause of failure amongst the studies included in this review.[14-19,23,26,27,29,32]

In a two-year prospective clinical trial by Ferrari, Cagidiaco[23] all failures (9 in total) were attributed to debonding of fibre posts. The authors assessed the influence of the amount of residual coronal dentine on the failure risk of 120 fibre posts placed in endodontically compromised premolar teeth. Six experimental groups were defined based on the amount of dentine left at the coronal level. The frequency of debonding failure was increased with a reduced number of remaining coronal walls. No failure was reported when there were 2, 3 or 4 coronal walls remaining in two years observation period.

Cagidiaco, Garcia-Godboy[27] in a three-year clinical trial placed 120 pre-fabricated fibre posts in 6 different groups of premolar teeth. The amount of remaining coronal walls determined each group. The three-year observation showed that all failures were associated with debonding in teeth with a reduced amount of residual dentine.

Adhesive failure of fibre posts has been investigated in laboratory studies and it was suggested that this could be related to the inability of proper bonding to the root surface and remaining supragingival dentine.

Ferrari, Mannocci[33] argued that the adhesive problem could be associated with the actual morphology of the root canal. It is known that there are differences in dentinal tubules density and orientation in the root canal system. Deeper into the root canal, a reduced density of tubules was seen and a thinner hybrid layer is formed during bonding. However, the density of tubules changes only in the apical region, which would be below where a post would be placed. In addition, since bonding occurs to intertubular dentine, areas with reduced tubule density should achieve better bonding.

The configuration factor (or c-factor) is the ratio of bonded to unbonded surfaces and is known to affect dentine bonding procedure. Yoshikawa, Sano[34] in an *in vitro* study concluded that any ratio greater than 3:1 is unfavorable for bonding whereas in the root canal system the ratio might be 100:1.[35] It was demonstrated that strong bonding after acid etching could be achievable as a result of the increase in dentine surface area, however not all areas respond equally to etching.[33] Vichi, Grandini[36] proposed this could be due to pressure difference in the cervical and apical thirds during the bond application, which may result in resin penetrating less deeply into the tubules, leaving lateral branches unfilled. The authors also explained that differences in resin tag density and morphology at different regions of root canal compared to coronal ones may occur as a result of inability of primer-adhesive solution to penetrate the opened dentinal tubules deep inside the root canal.[36,37] However, a SEM analysis of demineralized bonded dentine demonstrated that there is a strong resemblance of resin tags to lamina limitans. The lamina limitans, which has a high content of glycosaminoglycans, is an organic structure that is lined along the length of dentinal tubules. The study did not prove that resin tags are entirely made of glycosaminoglycans, rather, there is no evidence that resin tags are entirely made of resin.[38]

Another issue with bonding could be related to the dentine smear layer, which is a mixture of organic and inorganic debris produced during instrumentation. It may not be possible to infiltrate dentinal tubules covered by smear layer with mild self-etching adhesives. Zehnder, Schicht[39] suggested that this problem could be overcome by using EDTA as part of an irrigation regime to remove the smear layer.

It has been documented that fibre posts become more flexible after water immersion.[6] More flexible fibre post may cause microleakage between the composite and the dentine and subsequently causing debonding and further complications.[40]

Another factor that may have an effect on bonding of the fibre posts is the use of eugenol-containing sealers or cements during endodontic therapy or temporary restoration. These compounds are capable of penetrating into root canal dentine and inhibit the composite luting resin polymerisation process.[41] In an *in vitro* study it was also shown that eugenol has a "softening" effect on the resins found in provisional restoration materials. Furthermore, It was shown that the contact of eugenol with root canal dentine also significantly alters the penetration of dentine bonding agents.[42] Tjan and Nemetz[43] have suggested rinsing the bonding area with alcohol is useful if a eugenol-based sealer has been used to fill the root canal. Additionally, mechanical instrumentation of root canal for post preparation may remove the eugenol-containing dentine.

ROOT FRACTURE

It has been hypothesized that metal posts have high elastic moduli (~200 GPa) in comparison with that of dentine (~18 GPa) and fibre posts (~9-51 GPa), which could contribute to higher stress concentration on the root and promote higher risk of catastrophic failure and root fracture.[44-46] In contrast, a finite element analysis of fibre posts has shown that when the bonding between the fibre posts and the root canal surface failed, it resulted in higher stress concentration on root structures in comparison with the metal posts.[47] However, the authors in the same study have indicated that the metal posts caused more root fractures.

As can be seen from Table 2, root fractures occurred in 7 of the included prospective trials. In a seven-year randomised controlled clinical pilot trial, Sterzenbach, Franke[31] compared the biomechanical concept of tapered glass fibre posts in 45 individuals versus tapered titanium posts placed in 46 subjects. Results indicated that 92% survival rate in a mean 71.2 months with 3 failures in fibre posts were all associated with root fracture and 3 failures in titanium posts were all due to endodontic reasons. The authors included only teeth with two or fewer remaining coronal cavity walls and residual root canal thickness at the orifice of more than 1 mm. Sterzenbach, Franke[31] clinical trial was conducted according to the CONSORT guidelines and is the only study that reported root fracture as the most frequent cause of failure of fibre posts. Despite the authors claim that the failure of fibre posts was significantly dependant on fibre post material, this author argues that the taper design of the posts could potentially contribute to root fracture. It is known that tapered posts have the so-called "wedging effect" in the root canal system.[48]

Fokkinga, Kreulen[49] conducted a systematic review of *in vitro* studies and concluded that prefabricated flexible fibre post systems reduce the risk of root fracture when compared them to those of custom-cast, prefabricated metal and ceramic post systems.

A recent systematic review[50] of randomised controlled trails and cohort studies that reported on the incidence of root fracture associated with metal and fibre post-retained restorations, the results demonstrated that the overall rate of

Table 1. List of included prospective clinical trials

Study	Type of post assessed	Study design	Mean follow-up (months)	Amount of remaining residual coronal tooth structure
Glazer (16)	CFRC		28	≥ 2 mm ferrule
King, Setchell (17)	CFRC vs Gold Alloy Pre-fabricated (GAPF)		87	NS
Malferrari, Monaco (18)	Æstheti-Plus quartz-fiber		30	0 to 100%
Monticelli, Grandini (19)	1:Aestheti-Plus Fibre 2:DT (RDT) Fibre 3:FRC Postec Glass Fibre		24	2 walls remaining
Mannocci, Qualtrough (20)	Carbon fibre		72	NS
Naumann, Blankenstein (21)	Glass fibre		24	1-5 walls remaining
Naumann, Blankenstein (22)	Glass fibre		39	NS
Ferrari, Cagidiaco (23)	DT (RDT) Quartz fibre		24	6 groups:
Naumann, Sterzenbach (24)	Titanium vs Glass fibre		27.9	2 mm ferrule
Piovesan, Fernando Demarco (25)	Polyethylene fiber-reinforced		97	1.5 mm ferrule
Schmitter, Doz (26)	Glass fibre (FRP) vs Metal Screw (MSP)		13.84	Mean 3.4 mm ferrule
Cagidiaco, Garcia-Godboy (27)	1) No root canal retention 2) Fibre DT Light Post (LT) 3) Customized fibre post		36	6 ferrule groups
Mancebo, Jimenez-Castellanos (28)	Zircon-rich glass fibre embedded in an epoxy resin matrix		2.8	Group A: 2mm ferrule Group B: no ferrule
Zicari, Van Meerbeek (15)	1) Prefabricated Glass Fibre; 2) Custom Glass Fibre; 3) Composite cores, no posts; 4) Cast gold		21	1.5-2.0 mm ferrule
Schmitter and Hamadi (29)	1) Glass fibre; 2) Titanium Screw		61.37	
Ferrari, Vichi (14)	Group 1: No root canal retention Group 2: Glass fibre DT Light Post Group 3: Customized fibre post		72	6 ferrule groups
Naumann, Koelpin (30)	Glass-Fibre-reinforced post		120	≥ 1 cavity walls
Sterzenbach, Franke (31)	Glass fibre reinforced vs Titanium		71.2	< 2 cavity walls
Sarkis-Onofre, Jacinto (32)	Glass fibre vs Cast metal		19.2	0-0.5 mm of ferrule

NS: Not specified; CFRC: Carbone fibre reinforced composite;

Core material used for fibre posts	Fibre post cementation material	Type of final restoration	Overall survival rate (%)
Composite resin	MetaBond cement	PFM crowns & FPDs	89.6
Type III gold alloy	CFRC: Composite GAPF: Zinc Phosphate	PFM crowns	CFRC: 71 GAPF: 89
Core-Flo® / Bis-Core®	AllBond2® resin Cement	All ceramic & PFM	98.3
Flowable composites 1 and 2: AEliteFlo®, Bisco® 3:TetricFlow®	1&2: One-Step® bond + resin cement 3: DSC bond+ resin cement	All ceramic	93.8
Composite	AllBond2 + C&B Bisco®	Direct composite	90
Clearfil Core®	EBS® Multi + Compolute®	All-cermaic & PFM	88.6
Clearfil Core®	EBS® Multi + Compolute®	All-cermaic & PFM	Annual failure: 6.7
Flowable and microhybrid composite	Prime&Bond NT + Calibra	PFM crowns	92.5
Composite	Self adhesive resin	Single Crown, FPD and combined RPD	100
Composite resin	Dual-cure resin	All ceramic/direct composite	90.2
Flowable adhesive + Dentine adhesive	Composite cement (Variolink II)	Single crown, FPD and RPD	FRP: 93.5 MSP: 75.6
LT: XFlow® or CeramX® composite ES: Bis-Core®	LT: Prime&Bond® + Calibra® ES: AllBond2+Bis-Core®	Single PFM crowns	Overall: 76.6 1) 62.5; 2) 90.9; 3) 76.7
Resin composite (Dentocore Automix)	Self-adhesive resin cement / RelyX Unicem	PFM or All ceramic	With ferrule: 93.3 No ferrule: 73.8
Clearfill Composite + Clearfil self-etch adhesive	Panavia® F 2.0	All ceramic	97.1
Flowable adhesive	Composite cement		1): 71.5 2): 50.0
LT: XFlow or CeramX composite ES: Bis-Core	LT: Prime&Bond® + Calibra® ES: AllBond2+Bis-Core®	Single PFM crowns	94.1
Composite resin	EBS® Multi + Compolute®	All-cermaic & PFM	Annual failure: 4.6
Composite resin	Self-adhesive resin	5 various restorations	Fibre: 90;Titanium: 93.5
Composite resin	RelayX®	Single PFM crowns	Fibre: 97/ Cast: 92

root fractures was similar between metal (5.13 per 1000 post years) and fibre posts (4.78 per 1000 post years). However, carbon fibre posts and pre-fabricated metal posts were twice as likely to cause root fracture than cast metal posts and glass fibre posts respectively.

One could conclude from data provided in the included prospective studies that root fractures were more likely to occur where there was no or less than 2 mm of remaining coronal dentine present. The influence of the remaining coronal tooth structures will be discussed in details in risk factors section.

Post fracture

Post fractures were reported in six clinical trials of which four trials reported root fracture as the most frequent cause of failure of fibre post *(Table 2)*.

Naumann, Blankenstein[21] reported 58% of all failures (12 failures in total) were due to post fracture in 105 fibre-reinforced posts placed in teeth with varying degrees of hard tissue loss. In this trial, tapered glass fibred posts were compared with parallel-sided, serrated ones. The authors concluded that parallel-sided and tapered glass fibre posts gave an equal rate of survival after 2 years of clinical service. The authors indicated details of fibre posts were placed in teeth required post and core restorations e.g. post size, post length, however it was not shown that which posts had more fracture in terms of post size or length. Interestingly, it was observed that all post fractures occurred when teeth has one or lesser cavity walls. It can be speculated that such a defect extension can be regarded as a critical factor when high functional stresses applied on post and core without any support by adjacent natural teeth against occurring shear forces. Short observation period and limited statistical data make it difficult to draw firm conclusions.

In a later study of 10-year survival evaluation of glass fibre posts, Naumann, Koelpin[30] observed 17 failures due to post fracture (30% of all failures). The authors stated that incisor or canines had a 2-fold increased mechanical failure rate compared with premolar and molar teeth. It was proposed that this could be due to higher horizontal forces causing tension stress acting on anterior teeth compared with a more perpendicular compressive force vector for posterior teeth.

Mancebo, Jimenez-Castellanos[28] in a 3-year clinical trial evaluated the survival of 87 zircon-rich glass fibre posts. Two experimental groups, according to the presence or absence of ferrule, were defined: A) 45 teeth with ferrule (>2 rom height); and B) 42 teeth without ferrule «2 rom height). After 3 years 14 failures occurred, 4 of those related to post fracture. It was explained that the high rate of post fracture in their study could be related to rather low fatigue resistance of fibre posts. The presence or absence of ferrule showed a statistically difference however, no data was provide of failure mode of each group according to the presence or absence of ferrule. In an *in vitro* study eight types of fibre post were evaluated for fatigue resistance. The authors found a statistically significant difference were present among the posts. Fibre posts with a diameter of 2 mm appeared to withstand practically all the stipulated number of load cycles.[51]

Normally, the size of a fibre post is chosen according to the size of a root canal so less tooth structure is removed. Therefore one could conclude that in smaller root canals, the risk of post fracture is higher. Prospective clinical studies assessing the effect of the diameter a fibre posts on fracture resistance need to be conducted.

Endodontic failures

Five prospective clinical trials reported the failure of fibre posts due to endodontic complications *(Table 2)*.

Glazer[16] reported the longevity of 59 carbon fibre posts in 47 patients over a mean of 28 months. The cumulative survival rate at the end of the follow-up was 89.6% with a mean survival time of 43.4 months. Only 4 failures were observed of which 2 were due to peri-apical pathology. The other two failures were due to debonding of the fibre post and core.

Monticelli, Grandini[19] evaluated the clinical performance of three different types of fibre posts placed in 225 premolar teeth over a follow-up period of 2 to 3 years. In 8 cases failure was associated with debonding and 6 premolar teeth failed due to endodontic complications (42.9% of all failures). The authors reported a 93.8% overall success rate over 2 years.

One could argue that endodontic failures are likely to occur with any particular post system considering the healing rate of primary root canal treatment has been reported elsewhere as 83%.[52] Unless there is higher risk of debonding as a result of increased stress concentration at the coronal end of more flexible fibre posts and subsequent coronal leakage.

Secondary caries

Three trials reported secondary caries as a cause of failure of fibre posts.[20,28,30]

In a five-year randomised controlled trial of endodontically treated premolar teeth with amalgam or with carbon fibre posts, Mannocci, Qualtrough[20] reported 10 failures at 5 year follow-up (out of 97 carbon fibre posts placed in premolars) all associated with secondary caries. In amalgam-restored premolars, only 3 failures were associated with caries. It is worth mentioning that the operators did not provide a crown or cuspal coverage for these restored teeth.

Mancebo, Jimenez-Castellanos[28] believes that caries is likely to occur mainly as a consequence of a patient's oral hygiene measure and diet considerations rather than related to fibre posts. However, as noted earlier in this review, increased stress concentration at the coronal end of more flexible fibre posts may lead to microleakage hence increased risk of debond and development of caries.[40]

RISK FACTORS

Prospective trials have identified that many factors influence the survival of endodontically treated teeth restored with fibre posts including tooth type and its position in the dental arch, the type of final restoration and the occlusion.

Remaining residual tooth structure

Many of the studies included investigated the association of failure of fibre posts to the remaining residual tooth structure that can contribute to the "ferrule effect" *(Table 1*).

The ferrule effect has been defined as "a 360° metal collar of the crown surrounding the parallel walls of the dentine extending coronal to the shoulder of the preparation".[53] A ferrule is designed to prevent root fracture[54] and enhance the structural integrity of endodontically treated tooth by stabilising the functional lever forces.[55]

In vitro studies using metal posts confirmed that the ferrule effect will reduce the root fracture rate of teeth with post and core restorations.[56,57] However, Pereira, De Ornelas[57] found no statistically significant difference in failure loads when compared canine teeth restored with a custom post and core with 1 mm height of ferrule and those with no ferrule. In another *in vitro* study the operators evaluated the effect of ferrule height in teeth restored with either fibre post or zirconia dowel systems. It was noted that teeth with 0.5 mm and 1 mm ferrule failed at a significantly lower number of load cycles than the teeth with 1.5 mm to 2 mm ferrule.[58]

Also in vivo studies assessing different types of post systems confirm that a uniform ferrule of 1.5-2.0 mm is deemed to be the minimal effective height of coronal dentine in order to increase fracture resistance.[27,53,59,60]

In this review six of the included prospective clinical trials assessed the survival of endodontically treated teeth restored with fibre posts with different ferrule height and they all observed that the risk of failure was significantly higher for teeth that had no or less than a 2 mm ferrule.[14,23,27,28,30] Naumann, Koelpin[30] in a 10-year longitudinal evaluation of glass fibre posts observed 55 failures in 149 posts placed in 119 patients, resulting in an average annual failure rate of 4.6%. Statistical analysis revealed that 70% of failures (39 out of 55) were in teeth with 1 or less remaining cavity walls.

Ferrari, Vichi[14] evaluated the contribution of remaining coronal walls of pulpless premolar teeth restored specifically with fibre posts was assessed over six years of clinical service in a randomised clinical trial. Premolar teeth with 4 coronal walls had 100% success whereas premolar teeth with one remaining coronal wall had a reduced success rate of 77.8%. Those premolar teeth restored with fibre post, which had no ferrule succeeded only 38.9% followed over 6 years of clinical service.[14]

Results from a 17-year prospective study[60] indicated that in a pulpless tooth with "substantial dentine height" a post would not affect the survival probability thus one could argue that 100% success rate of teeth with 4 coronal walls in Ferrari *et al*. 2012 study, was not absolutely related to the use of fibre posts and that any post material would have been successful. In this study "Substantial dentine height" was defined as: >75% of the circumferential dentine wall has minimal 1 mm thickness and at least a height of 1 mm above gingival level; less than 25% of the circumference has less than 1 mm above the gingiva, but a ferrule of 1–2 mm could be achieved (Fokkinga *et al*. 2007).

Interestingly, despite the fact that the majority of studies referred to the ferrule effect as a positive factor in restoration of endodontically treated teeth, in the Ferrari, Cagidiaco[23] clinical trail, the authors found no difference between survival of premolar teeth restored with or without minimum ferrule effect when restored with fibre posts (the percentage of failure was 35% and 40% for premolars with or without minimum ferrule, respectively). Schmitter, Doz[26] also, observed that a ferrule did not have an influence in survival of teeth restored either with glass fibre or titanium posts.

Position of the tooth in the dental arch

Many prospective clinical trials reported maxillary anterior teeth restored with fibre posts to fail more frequently than posterior teeth.[15,21,26,28,29] Observations revealed that there are different force directions in the anterior and posterior teeth (ie, higher horizontal forces causing tension stress acting on anterior teeth compared with a more perpendicular compressive force vector for posterior). Consequently, the maxillary teeth are believed to bear higher horizontal or lateral forces.[61]

Naumann, Koelpin[30] reported a 2-fold higher failure rate of anterior teeth than posterior teeth. Increased rate of failure was also confirmed by Schmitter, Doz[26] and Mancebo, Jimenez-Castellanos.[28] In contrast, Piovesan, Fernando Demarco[25] reported no difference between anterior and posterior teeth and Glazer[16] observed more failures in premolars than incisors teeth.

Type of final restoration

A 97-month prospective study evaluated 3 types of final complete-crown coverage restorations when used to restore endodontically treated teeth with fibre-reinforced custom posts. No difference was found between resin composite, all-ceramic and porcelain-fuse-to-metal restorations.[25]

Results of this trial are in line with the results of two other studies that assessed different post-retained restorations.[13,62] Although results from a recent systematic review,[63] which investigated the success rate of prosthetic restorations on endodontically treated teeth reported 94% success rate of single crowns on endodontically treated teeth without a post whereas when a post was placed the success rate was lower (92%).

Table 2. Failure mode of fibre posts in the included prospective clinical trials

Study	Most frequent cause of failure No. of failures/total No. posts (% of total failures)	2nd most frequent cause of failure No. of failures/total No. posts (% of total failures)
Glazer (16)	Debonding 2/59 (50%)	Endodontic 2/59 (50%)
King, Setchell (17)	Debonding 4/16 (100%)	-
Malferrari, Monaco (18)	Debonding 3/180 (100%)	-
Monticelli, Grandini (19)	Debonding 8/225 (57.1%)	Endodontic 6/225 (42.9%)
Mannocci, Qualtrough (20)	Caries 10/97 (100%)	-
Naumann, Blankenstein (21)	Post fracture 7/105 (58.3%)	Debonding 2/105 (16.6%)
Naumann, Blankenstein (22)	Post fracture 14/149 (45%)	Debonding 9/149 (29%)
Ferrari, Cagidiaco (23)	Debonding 9/120 (100%)	-
Naumann, Sterzenbach (24)	No failure (0%)	-
Piovesan, Fernando Demarco (25)	Post fracture 5/109 (83%)	Debonding 1/109 (17%)
Schmitter, Doz (26)	Debonding mainly 3/50	-
Cagidiaco, Garcia-Godboy (27)	Deboning 11/120 (100%)	-
Mancebo, Jimenez-Castellanos (28)	Post fracture 4/87 (28.5%)	Caries 4/87 (28.5%)
Zicari, Van Meerbeek (15)	Debonding 1/91 (100%)	-
Schmitter and Hamadi (29)	Debonding 8/39 (88%)	Endodontic 1/39 (11%)
Ferrari, Vichi (14)	Debonding 12/114 (48%)	Endodontic 7/114 (28%)
Naumann, Koelpin (30)	Debonding 20/149 (36%)	Post fracture 17/149 (30%)
Sterzenbach, Franke (31)	Root fracture 2/41 (50%)	Core failure 1/41 (25%)
Sarkis-Onofre, Jacinto (32)	Debonding 2/37 (66.6%)	Root fracture 1/37 (33.3%)

3rd most frequent cause of failure No. of failures/total No. posts (% of total failures)	4th most frequent cause of failure No. of failures/total No. posts (% of total failures)	Other causes of failure No. of failures/total No. posts (% of total failures)
-	-	-
-	-	-
-	-	-
-	-	-
-	-	-
Root fracture 1/105 (8.3%)	Core failure 1/105 (8.3%)	1/105 (8.3%)
Root fracture 3/149 (9.6%)	Core failure 3/149 (9.6%)	2/149 (6.8%)
-	-	-
-	-	-
-	-	-
-	-	-
-	-	-
Root fracture 2/87 (14.2%)	Deboning 1/87 (7.1%)	3/87 (21.3%)
-	-	-
-	-	-
Post fracture 5/114 (20%)	Root fracture 1/114 (4%)	-
Endodontic 7/149 (12.7%)	Root fracture 5/149 (9%)	6/149 (11%)
Periodontal 1/41 (25%)	-	-
-	-	-

Single crowns over cast post-and-core and prefabricated posts showed a success rate of 93% and 94%, respectively. Also, in this study, single crowns on endodontically treated teeth performed significantly better than fixed partial dentures (92% versus 79% respectively). However, Naumann, Blankenstein[22] indicated that those teeth, which received a fibre post and a single crown as final restoration had 4 times greater failure rates than teeth restored with fixed bridges. It was explained that high failure could be related to vestibule-oral direction of the forces normally applies on single crowns.[22]

Consideration of occlusion and parafunction

There is a lack of clinical studies, which evaluated the role of occlusion in teeth restored with fibre posts. Mehta and Millar[64] in a retrospective study of 129 teeth restored with fibre posts with two different types of luting cements suggested that in patients with higher occlusal loads e.g. bruxists, resin-fibre posts should be avoided. This is due to the reduced strength and elastic limit of these posts compared to metallic posts predisposing to post fracture. Torbjorner and Fransson[61] state that designing the definitive prosthesis with a more favorable occlusal direction is highly critical for the survival of endodontically treated tooth than the type of post is used.

The authors encourage future studies to include some essential baseline factors regarding the occlusion. 3D and finite element analysis would be advantageous.

Other risk factors

The design of fibre post could influence the survival probability of this restoration. Torbjörner, Karlsson[48] has shown that parallel-sided serrated metal posts had significantly higher success rate than custom-cast tapered posts over 5 years. It is believed that parallel posts resist tensile, shear and torqueing forces better than tapered posts and distribute stress more uniformly along their length during function.[65] In a 5-year prospective clinical trial parallel-sided fibre posts performed slightly better than tapered ones in anterior teeth with 98.6% and 96.8% survival rates respectively however the indicated figures does not appear to be significant.[66]

The patient's gender could be another risk factor for the failure of fibre posts. Sarkis-Onofre, Jacinto[32] expect men to have a higher chance of failing post-retained crowns due to their greater occlusal strength. However, due to poor reporting of gender impact on failure of fibre posts, there is no evidence to support this statement.

Longevity of fibre posts versus other posts

Six prospective studies reviewed in the present paper compared survival rate and mode of failure of fibre post and metallic posts. Three studies have shown no difference in survival rates of these posts.[24,31,32] Two clinical trials have shown a higher survival rate of fibre posts when compared to metallic posts[26,29] and one trial indicating lower survival of carbon fibre posts against gold alloy prefabricated posts.[17]

A Cochrane-based systematic review has compared the failure rate of fibre and metal posts but was unable to demonstrate with posts perform more predictable. However, the review was limited to randomised controlled trails and only one study with high risk of bias was included.[67] Fewer failures were occurred with carbon fibre post in comparison with metal posts.[68] Conversely, another systematic review included 10 randomised controlled trails with high risk of bias and wide heterogeneity of study designs; it was concluded that glass fibre posts show significantly better results than metal screws and quartz fibre posts.[69]

DISCUSSION

Selection of a post for restoration of endodontically treated teeth remains controversial as the results from different studies vary. Wide variations in group design and non-standardized treatment protocols including ferrule preparation, the amount of remaining tooth structure and several other factors, which may influence the survival of posts make it difficult to compare outcomes in papers included in this review.

Many of available evidence in previous literature suggest that presence of 1.5 to 2.0 mm ferrule provide better prognosis of fibre posts.[70,71] Conversely, many authors in the included prospective trails assessed the ferrule height after root canal treatment and before abutment preparation. However, the loss of remaining tooth structures due to preparation of finishing margins and axial walls was not considered. This may overestimate the amount of ferrule in many teeth included in clinical trials. Additionally, the ferrule should be evaluated with respect to its height and circumferential extension. Unfortunately, this has not been taken into account in many clinical trials.

Another factor that must be taken into consideration is the feasibility of fibre post removal when it might be necessary for endodontic reasons. Post fracture is a recognised complication of metal-based posts when removal is necessitated. Additionally, it certain situations it may not be possible to remove a metal post. Specially designed reamers have been developed for removal of fibre post with progressive drilling through the centre of the post. However, one should be careful to avoid weakening of root structures and further complications such as root perforation. Also, some fibre post systems and their luting cements are tooth coloured thus they are not easy to be seen in the root canal and this may complicate the removal of the post. Recherches Techniques Dentaires (RTD) has overcome this problem with their D.T. light-Post system. These posts have a temperature-sensitive colour added to them; at body temperature they are tooth-coloured, however when cooled with water, the colour reappears, assisting in their removal if required.

CLINICAL RELEVANCE

Fibre posts can be used as a reliable restorative material for reconstruction of pulpless teeth where a post is indicated to retain the core material. It is crucial to acquire all the baseline information prior to selecting which post system is indicated for restoration of a tooth considering the risk factors, long-term prognosis, patient's expectations and costs. A tooth with no remaining coronal dentine may not be a candidate for any post-and-core systems therefore; crown lengthening procedures or extraction and prosthetic replacement of the missing tooth may be a more predictable alternative.

The authors suggest the following recommendations for minimising the failures associated with fibre posts:

1. Parallel-sided posts have shown to perform more predictable than tapered posts
2. Proper isolation during cementation of fibre posts is beneficial, preferably using rubber dam. However, as yet there is no evidence to support the application of rubber dam for placement of posts will influence the longevity of the posts.
3. Complete removal of gutta-percha and irrigation of root canal with EDTA will maximise the retention of the post.
4. Rinsing the root canal with ethanol reduces the inhibiting effect of eugenol containing endodontic sealers hence reduce risk of adhesive failure.
5. Wider diameter (thicker) fibre posts tend to fracture less often than the thinner one (however, it is advisable not to over-prepare the root canal in order to place a thicker fibre posts as this may weaken the tooth structure). In smaller root canals, alternative posts systems may be used.
6. It has been shown that water degrades mechanical properties of fibre posts thus it is advisable to avoid water or saliva contamination.

CONCLUSIONS

1. The available evidence does not indicate a difference in short-term survival probability between metal or fibre posts.
2. The bulk of evidence suggest that the presence of a ≥ 2 mm ferrule and remaining coronal dentine play a significant role in survival rate of a fibre post. The less remaining coronal dentine, the higher risk of failure.
3. No difference was found in the survival probability of an endodontically treated tooth with substantial remaining coronal tooth structure restored with a post-and-core or a post-free core.
4. All risk factors must be considered as a part of the planning scheme prior to placement of a fibre post in order to minimise the risk of failure of fibre posts.
5. Retrievability of a tooth after placement of a post must be taken into consideration. It might be easier to remove a fibre post, if necessary, compared with metal-based posts cemented with resin cements into the root canal, however due to the lack of evidence some clinicians may disagree with this statement.
6. There is considerable variation in the reported causes of failure of fibre post systems thus well-structured longer-term clinical trails are required in order to be able to draw firm conclusions.

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