

Comparing Techniques for Removing Fiber Endodontic Posts: A Systematic Review

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ABSTRACT

Aim: This systematic review aimed to establish the available techniques for fiber post removal, pointing out where each method stands out evaluating its advantages, and where they fall short indicating the possible harmful effects.

Materials and methods: This systematic review was registered in PROSPERO (CRD42020193799). A broad search of the electronic databases PubMed, Web of Science, Scopus, and Virtual Health Library was carried out before April 27, 2020, for *in vitro* studies about techniques for removing fiber posts luted with resin cements of endodontically treated teeth. The methodological quality of included studies was evaluated based on the critical assessment tool for *in vitro* studies.

Results: Thirteen articles were selected and included after applying the inclusion and exclusion criteria. All included studies received an assessment of methodological quality between high and moderate. Most studies used ultrasonic inserts as a strategy to remove fiber posts, manufactured removal kits and drills were also widely used, only one study evaluated the removal capacity of the Er:YAG laser. Ultrasonic inserts seem to lead to a greater working time for removal of the fiber post, tend to generate significant volume changes in the root structure and increase the temperature on the root canal and clean the root canal walls further.

Conclusion: Although the results tend to show greater agility in removing fiber posts with manufactured removal kits and the ultrasonic inserts seem to work better in removing fiber remains and luting agent, there is still no consensus in the literature as to which technique is the best.

Clinical Significance: In some cases, clinicians may be faced with the need to remove fiber posts in order to regain access to the root canal due to the need for endodontic retreatment which directly implies the search for the most appropriate removal technique.

Keywords: Fiber posts, Post and core technique, Post removal, Systematic review.

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INTRODUCTION

Technical deficiencies during the chemical-mechanical preparation of the root canal can result in insufficient disinfection, leading to the maintenance of bacterial infection in the canal at levels sufficient to sustain periradicular inflammation¹ after root canal treatment. In these cases, root canal retreatment procedures are required and can bring challenges during therapy, such as removing intraradicular posts.²

Post-and-core systems are widely used in endodontically treated teeth,³ the use of fiber posts and resin cores has increased due to their mechanical and aesthetic properties, which merge adequately with permanent restorations.⁴ The fiber post material consists of filaments of carbon, quartz, silica, zirconia, or glass embedded in an epoxy resin matrix. The modulus of elasticity of fiberglass posts is similar to that of radicular dentin, significantly reducing the probability of root fracture, which is the most frequent cause of failure with metallic posts.^{5,6} A post with a modulus of elasticity greater than that of dentin can create stress at the tooth/post interface, possibly resulting in post dislodgment and consequent failure.⁷

Posts of various, and sometimes unknown, materials might need to be removed in clinical practice. Therefore, the establishment of a standard technique for the removal of any post system would be beneficial.⁸ In general, the efficient adhesive procedures and a similar modulus of elasticity as dentin hinder the removal of fiber posts.^{4,7} Current removal techniques involve the use of burs (diamond, Gates Glidden, Largo, Peeso, and burs of removal kits from post systems), ultrasound, and laser, each varying in procedure time and preservation of the dental structure.^{3,4,9-11}

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In this context, the removal of the fiber post, either due to failure of endodontic treatment or to improve the aesthetics or mechanics of a new restoration,⁸ remains a major challenge for contemporary endodontics.⁹ Removal needs to be atraumatic, with the concern to protect the root canal structure offering resistance for long-term tooth retention,² since the removal procedure raises concerns about the appearance of cracks or root fractures and becomes an important consideration in the selection of a treatment method and tooth prognosis.¹⁰

Thus, the selection of the techniques for removing fiber posts luted with resin cements might consider aspects, such as agility, effectiveness (full removal of the post and cement without damage to the root structure), and safety. Therefore, the purpose of this study was to carry out a systematic review of the literature and establish the available techniques for fiber post removal, pointing out where each method stands out evaluating its advantages, and where they fall short indicating the possible harmful effects.

METHODS

This systematic review was reported in accordance with the PRISMA (preferred reporting items for systematic reviews and meta-analyses) principles and standards¹² and the protocol was registered in the PROSPERO database (record number CRD42020193799).

The focus question of this systematic review was “Which technique for removing fiber posts luting with resin cement in endodontically treated teeth is more appropriate?”

Eligibility Criteria

The PIO strategy used for selecting the studies was “population”: endodontically treated teeth; “intervention”: techniques for removing fiber posts luting with resin cement; and “outcome”: final removal of fiber posts. *In vitro* studies on removing fiber posts luted with resin cements were included.

The exclusion criteria were the literature reviews, studies with only evaluated metal posts, use other than resin cements, studies using traction test, push-out or pull-out, and adhesion assessment of which did not evaluate post removal either, duplicated studies, clinical studies, case, and technique reports.

Screening and Selection of Studies

Two independent researchers (L.O.T.P. and R.L.) performed a wide search for articles published before April 27, 2020, without language restrictions. The starting date considered for the search of the articles was 1950. The databases searched were PubMed, Web of Science, Scopus, and Virtual Health Library (VHL) using keywords and standardized vocabulary (MeSH terms) to represent the concepts of “fiber posts” and “removal.” MeSH synonyms, related terms, and free terms were included, as well as their combination and the search strategy are described in Table 1. The gray literature

Table 1: Search strategy used for each database for articles published before April 27, 2020

Database	Search strategy
PubMed	((((((((Fiberglass[MeSH Terms]) OR glass fibers[Title/Abstract]) OR Fiberglass [Title/Abstract]) OR Post core[Title/Abstract]) OR Fiber post[Title/Abstract]) OR fiber post*[Title/Abstract])) AND (((removing[Title/Abstract]) OR Removal[Title/Abstract]) OR Remove*[Title/Abstract]))
Web of Science	TITLE: (glass fibers) OR TITLE: (FIBERGLASS) OR TITLE: (Post core) OR TITLE: (Fiber post) OR TITLE: (fibre post*) AND TITLE: (removing) OR TITLE: (Removal) OR TITLE: (Remove*)
Scopus	(TITLE-ABS-KEY (glass AND fibers OR fiberglass OR post AND core OR fiber AND post OR fibre AND post*)) AND TITLE-ABS-KEY (removing OR removal OR remove*)
VHL	'(glass fibers OR FIBERGLASS OR Post core OR Fiber post OR fibre post*) AND (removing OR Removal OR Remove*)

was searched in the platforms “The Gray Literature,” “Networked Digital Library Theses and Dissertations,” “BDTB,” and “Open Gray.”

Initially, two independent examiners (L.O.T.P. and R.L.) screened titles and abstracts and selected that based on the inclusion criteria. In case of uncertainty, the article was included for full-text analysis. Disagreements were solved by a third reviewer (M.Z.S.), who determined whether or not to include the article.

Quality Assessment

The quality assessment of the included articles was based on the critical assessment tool as described in previously published *in vitro* studies.^{13–15} There are seven domains that address: the randomization of samples; use of teeth free of caries; restorations or fractures; use of instruments according to the manufacturer’s instructions; use of teeth with similar dimensions; the execution of treatment carried out by a single operator; description of the sample size calculation and the blindness of the examiners.

Each investigated aspect receives a “Y” that means yes if the domain was described, and an “N” referring to no if it was not possible to identify the information. The final sum of responses characterized the articles as “high risk of bias” if they added 1 to 3 yes responses, “medium risk of bias” 4 to 5, and “low risk of bias” 6 to 7 items.

Data Extraction

The data of the included studies were entered in spreadsheets and analyzed using Excel software (Microsoft, Washington, USA). Two researchers (L.O.T.P. and R.L.) conducted the analyzes independently.

The data were organized according to (1) the author and year of publication; (2) the type and sample size; (3) the removal technique used; (4) the studies objective; (5) evaluation method; (6) the results in detail; and (7) the conclusion.

RESULTS

Data Search and Selection of Articles

Based on the search strategy, 1545 articles were found, being 250 in PubMed, 64 in Web of Science, 278 in Scopus, and 953 in VHL. No studies were found on the gray literature. Most of the excluded studies were because they were out of topic (663 studies) or because they did not address techniques for removing the fiber post (487 studies). After applying the inclusion and exclusion criteria, 13 articles were selected and included in this systematic review. The selection procedure is described in Figure 1.

Quality Assessment of the Risk of Bias

The results of the methodological quality analysis are shown in Table 2. Just over half of the studies reported between 4 to 5 items classifying them as “medium risk of bias,”^{4,8–11,16,17} the remainder obtained “high risk of bias.”^{2,3,18–21} Only three studies did not randomize samples of teeth treated endodontically,^{4,10,20} and two studies did not report their use of instruments according to the manufacturer’s instructions.^{9,18} It is worth mentioning that only two studies reported the blindness of the examiners.^{9,20}

Main Characteristics of the Included Articles and Synthesis of Results

The main characteristics and the main results of the primary studies are shown in Table 3.

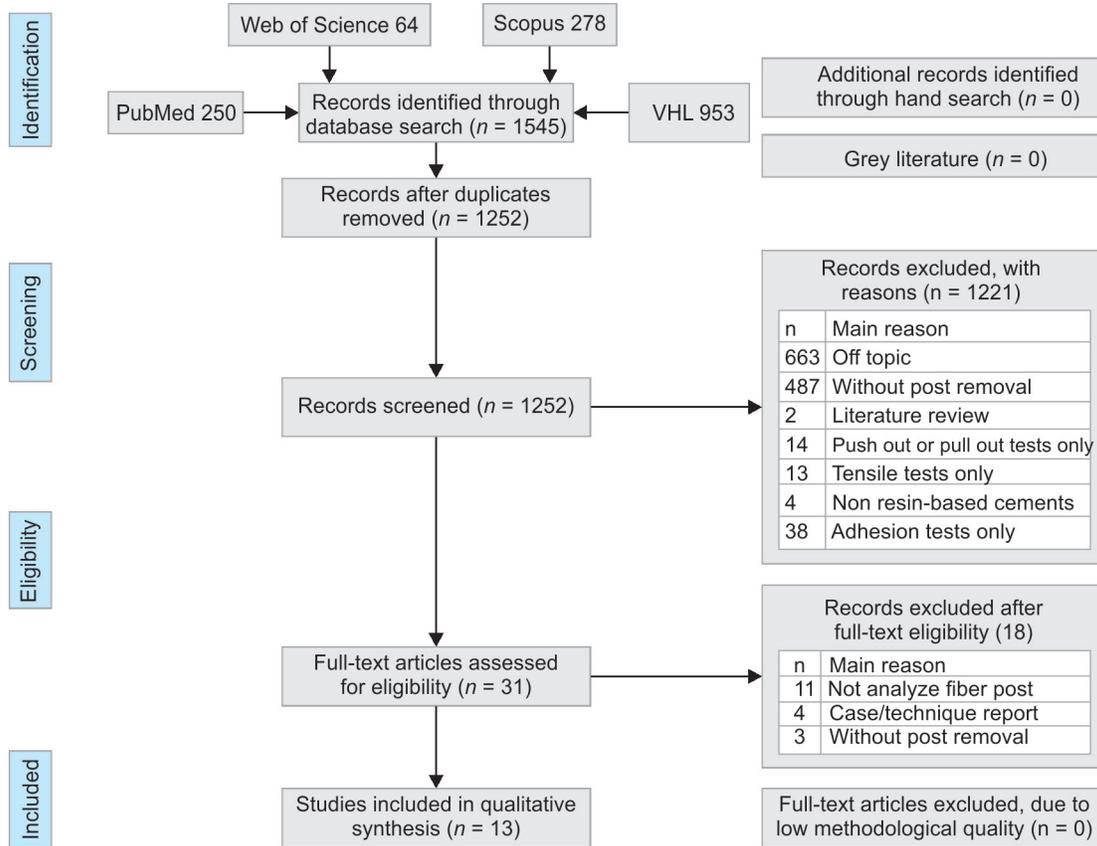


Fig. 1: PRISMA flow diagram

All studies used single-rooted teeth ranging from a total of 30 to 153 teeth. Most studies used ultrasonic inserts as a strategy for removing fiber posts,^{2,3,9,16-20} and sometimes associated with carbide⁹ or diamond burs.⁴ manufactured removal kits were also widely used.^{2,4,8,10,11,16,19,21} Only one study evaluated the removal capacity of the Er:YAG laser.³ Regarding the evaluated aspects, the time taken to fully remove the fiber posts in each technique was the most evaluated item,^{2-4,8,9,11,16,19-21} followed by changes in the surface or dental structure, such as volumetric changes,^{2,9,17,19} cracks and microcracks,^{2,3,10} and residual material present in the root walls.^{2,9} Four studies reported evaluating the effectiveness of removing the fiber post using quantitative and qualitative methods,^{4,8,19,20} and two studies evaluated effectiveness on residual material or volumetric changes and were mentioned previously.^{2,9} One study evaluated the fracture strength of the remnant after removing the fiber post.¹⁶ Taking into account the evaluation method, most studies analyzed images either obtained by micro-computed tomography (micro-CT)^{2,17} or by a microscope,^{3,4,8-10,20} and even thermographic images.¹⁸

Regarding effectiveness assessed, three included studies used the same scale which was defined by the following parameters: (1) only dentin can be seen after post removal; (2) only cement can be seen after post removal; (3) 25% of the fibers are left after post removal; (4) 25 to 50% of the fibers are left after post removal; and (5) 50% of the fibers are left after post removal.^{4,8,20} Scotti et al.²⁰ also observed the difference

in weight before and after removal to assess wear within effectiveness.

The synthesis of the results of the primary studies is shown in Table 4.

The use of ultrasonic inserts tends to generate significant volume changes in the root structure,¹⁷ also when associated with carbide burs⁹ and when compared to manufactured removal kits,² both results from only one primary study each. No significant impact on the initiation and spread of cracks was observed under manufactured removal kits,¹⁰ ultrasound and Er:YAG laser,³ also without a difference when comparing ultrasound and manufactured removal kits.²

Ultrasonic inserts seem to lead to a greater working time for removal of the fiber post when compared to manufactured removal kits,^{2,4,16,19} and Er:YAG laser,³ in association with burs the working time decreases but without statistically significant difference.⁹ The use of burs associated with the Largo drill also consumed less time compared to the manufactured removal kits.¹¹ Regarding effectiveness, the kits appeared to be less effective when compared to the use of burs^{4,8} and ultrasound.¹⁹

Concerning temperature, an increase was observed when ultrasonic inserts without cooling by continuous irrigation are used,¹⁸ and still showed higher temperatures when compared to Er:YAG laser.³

According to the selected articles, it can be said that the ultrasonic inserts and manufactured removal kits tend to stand out in the removal of fiber posts.

Table 2: Quality assessment of the included studies

	<i>Arukaskan and Aydemir²</i>	<i>Deeb et al.³</i>	<i>Capriotti et al.¹⁸</i>	<i>Aydemir et al.¹⁶</i>	<i>Haupt et al.¹⁹</i>	<i>Kim et al.¹⁷</i>	<i>Çapar et al.¹⁰</i>	<i>Abe et al.⁹</i>	<i>Scotti et al.²⁰</i>	<i>Frazer²¹</i>	<i>Anderson et al.⁸</i>	<i>Lindemann et al.⁴</i>	<i>Gesi et al.¹¹</i>
1. Teeth randomization	Y	Y	Y	Y	Y	Y	N	Y	N	Y	Y	N	Y
2. Teeth free of caries or restoration or root fracture	N	N	Y	N	N	Y	Y	N	N	N	Y	N	Y
3. Materials used according to the manufacturer's instructions	Y	Y	N	Y	Y	Y	Y	N	Y	Y	Y	Y	Y
4. Teeth with similar dimensions	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
5. Endodontic treatment performed by a single operator	N	N	N	Y	N	Y	Y	Y	N	N	Y	Y	N
6. Sample size calculation	N	N	N	N	N	N	N	N	N	N	N	N	N
7. Blinding of the examiner	N	N	N	N	N	N	N	Y	Y	N	N	N	N
Risk of bias	High	High	High	Medium	High	Medium	Medium	Medium	High	High	Medium	Medium	Medium

Y: yes; N: no; 1–3, yes (high risk of bias); 4–5, yes (medium risk of bias); 6–7, yes (low risk of bias)

Table 3: Main characteristics and outcomes of the included studies

<i>Author/Year</i>	<i>Sample</i>	<i>Removal technique</i>	<i>Study objective</i>	<i>Methodology</i>	<i>Detailed results</i>	<i>Conclusion</i>
<i>Arukaskan and Aydemir 2019²</i>	30 lower premolars	– D.T. light-post removal kit – Ultrasonic inserts	– Volumetric changes – Material residual – Working time – Microcracks	Micro-CT	– No significant differences were detected between groups on residual material and microcracks – Volumetric changes and working time was significantly higher in the ultrasonic group	– The D.T. light-post removal kit was faster and more conservative than the ultrasound
<i>Deeb et al. 2019³</i>	34 single-rooted teeth	– Er:YAG laser – Ultrasonic inserts	– Working time – Temperature – Structural damage	– Microthermal couple element (temperature) – Scanning electron microscope (structural damage)	The Er:YAG laser removal times were at least five times faster and the temperatures were lower than the ultrasonic with a statistical significance – The visual inspection of the teeth after post removal showed no sign of damage or cracks	Er:YAG laser can remove glass fiber posts faster with lower temperature increases compared to conventional ultrasonic devices
<i>Capriotti et al. 2018¹⁸</i>	40 single-rooted teeth (27 PM, 8 Inc, 5 Can)	– Ultrasonic inserts	– Temperature	– Thermo-graphic images	The dry use of ultrasonic inserts led to a more abrupt increase in temperature on the root surface to a maximum value of 46.6°C and the best results were obtained with the use of water cooling	– Recommendation to use continuous irrigation during the ultrasonic removal of the post

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Author/Year	Sample	Removal technique	Study objective	Methodology	Detailed results	Conclusion
Aydemir et al. 2017 ¹⁶	45 single-rooted teeth	– D.T. light-post removal kit – Ultrasonic inserts	– Working time – Fracture resistance after post removal	Universal testing machine (fracture resistance)	– The fiber post removal time for the ultrasonic group was significantly higher than the manufactured removal kit group – There was no significant difference between the control (no removal post) and manufactured removal kit groups, but the fracture resistance value of the ultrasonic group was found to be significantly lower than the manufactured removal kit group	Removal of the fiber posts with an ultrasonic tip decreases the fracture resistance of the roots compared to the manufactured removal kit, although significantly more time is required
Haupt et al. 2017 ¹⁹	153 single-rooted teeth	– DT-post removal kit – Long-shaft round bur – Ultrasonic inserts	– Volumetric changes – Working time – Effectiveness (material residual)	Computed tomography (volumetric changes and effectiveness)	– DT-post removal kit left significantly more residual material on carbon fiber post removal – The shortest time for post removal was achieved with DT-post removal kit – The least amount of removed dentin was detected when removal of the quartz fiber post was carried out with the DT-post removal kit	The highest effectiveness was achieved with the ultrasonic Inserts and the round bur. And The DT-Post removal Kit was faster
Kim et al. 2017 ¹⁷	48 upper anterior teeth and lower canines	– Ultrasonic inserts	– Volumetric changes	Micro-CT		– The ultrasonic removal of the fiber posts can generate significant volumetric changes in the root canal
Çapar et al. 2015 ¹⁰	60 lower premolars	– Rebuilda post system drills	– Cracks	Stereomicroscope	The effects of the procedure on crack propagation were no significant but the root was perforated in two samples. There was one new crack and one crack propagation in the samples after the post removal procedure	– No significant impact on the initiation and spread of cracks was observed
Abe et al. 2014 ⁹	45 upper canines	– Diamond bur + Largo bur – Ultrasonic inserts – Carbide bur + ultrasonic inserts	– Effectiveness (volumetric changes and material residual) – Working time	Operating microscope	– No significant differences were detected between groups on working time – Carbide bur + ultrasonic presented the largest number of samples with no remaining luting agent – Carbide bur + ultrasonic insert showed significant wear in relation to the diamond drill + Largo, since greater wear would mean less residual material for the authors of the primary study	Carbide bur + ultrasonic insert presented the most effective removal of glass fiber posts but there was no significant difference in efficiency among the evaluated techniques
Scotti et al. 2013 ²⁰	48 single-rooted teeth	– Ultrasonic inserts – Endodontic file + Largo burs	– Working time – Effectiveness	High-precision balance and microscope (effectiveness)	The removal time was significantly shorter for the endodontic file + Largo drill group with no difference in relation to the operator's expertise. There was no difference in removed sound radicular dentin between the techniques, but between the expertise of the operator	The endodontic file + Largo drill was faster in removing the fiber post, and both techniques were effectiveness

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Author/Year	Sample	Removal technique	Study objective	Methodology	Detailed results	Conclusion
Frazer 2008 ²¹	40 anterior teeth	Kodex K95 + Tenax Starter Drill + Manufacturer's drill	- Working time	Postremoval time record	This study confirmed that fiber posts can be more rapidly removed than titanium posts	In this work, only one post removal technique was performed and when compared to metallic post, it was faster
Anderson et al. 2007 ⁸	60 single-rooted teeth	- D.T. light-post removal kit - Kodex Twist/tenax para-post removal kit - Diamond burs + Peeso burs	- Working time - Effectiveness	Microscope (effectiveness)	- No significant difference in time between techniques - Effectiveness was higher with the diamond bur + Peeso compared with the Kodex twist/Tenax ParaPost drills, which in turn was more effective than the D.T. light-post removal kit	Fiber posts are efficiently (time) removed by all three methods studied but the effectiveness of removal is higher using the diamond bur/Peeso
Lindemann et al. 2005 ⁴	80 lower premolars	- Removal kit for the post manufacturer (ParaPost fiber white, luscent anchors, aestheti-plus, ruddle post removal system-PRS) - Diamond burs + ultrasonic tips	- Working time - Effectiveness	Microscope (effectiveness)	- The manufactured removal kit required significantly less removal time for each post type - Diamonds + ultrasonic tips were more effective than ParaPost Fiber White kit, but worse than ruddle post removal system-PRS	Fiber post removal speed was best obtained with manufactured removal kits and removal effectiveness was best achieved with ultrasonics and diamonds in general
Gesi et al. 2003 ¹¹	60 anterior teeth	- RTD fiber posts removal kit - Diamond burs + Largo burs	- Working time	Postremoval time record	Diamond and a Largo bur was less time-consuming than manufactured removal kits, and the difference was statistically significant	- The procedure using a diamond and a Largo bur was significantly less time-consuming

Table 4: Methods that showed the best results (by a studied variable) in primary studies

	Manufactured removal kits	Ultrasonic inserts	Burs + ultrasound	Burs + Largo/Peeso	Er:YAG laser
Less changes in the surface or dental structure	Arukaslan and Aydemir ² (kit vs. ultrasound) Haupt et al. ¹⁹ (kit vs. ultrasound vs. long-shaft round bur) Çapar et al. ¹⁰ (no comparison)	Kim et al. ¹⁷ (no comparison)		Abe et al. ⁹ (diamond burs + Largo vs. burs + ultrasound vs. ultrasound)	
Time	Aruskalan and Aydemir ² (kit vs. ultrasound) Aydemir et al. ¹⁶ (kit vs. ultrasound) Haupt et al. ¹⁹ (kit vs. ultrasound vs. long-shaft round bur) Lindemann et al. ⁴ (kits vs. diamond burs + ultrasound) Frazer ²¹ (no comparison)		Abe et al. ⁹ (diamond burs + Largo vs. burs + ultrasound vs. ultrasound)	Gesi ¹¹ (kits vs. diamond burs + Largo)	Deeb et al. ³ (laser vs. ultrasound)
Temperature		Capriotti et al. ¹⁸ (no comparison)			Deeb et al. ³ (laser vs. ultrasound)
Effectiveness		Haupt et al. ¹⁹ (kit vs. ultrasound vs. long-shaft round bur)*	Lindemann et al. ⁴ (kits vs. diamond burs + ultrasound)	Anderson et al. ⁸ (kits vs. burs + Peeso)	

*Ultrasonic inserts and long-shaft round but was more effectiveness



DISCUSSION

Despite the challenges in restoring severely compromised teeth, modern therapies in the field of endodontics, prostheses, and periodontics are allowing a long favorable prognosis.²² Thus, fiber posts are being widely used in these cases in order to ensure the retention of restorations through improved adhesion of fiber posts to the root canal,²³ a fact that becomes a problem for post retrieval when endodontic retreatment is indicated.² So this current systematic review aimed to evaluate the techniques available for removing fiber posts of endodontically treated teeth.

The use of fiber posts has increased considerably compared to metallic posts, either due to their aesthetic optimization or their compatibility with the elastic properties of dentin as mentioned before.^{4,13} However, the main cause of failure of these materials is still debonding from the interior of the root canal due to loss of adhesion.²⁴ Resin-based cements are commonly used for luting fiber posts with chemical, photoactivated, or double polymerization mechanisms that allow for easy clinical handling, favoring polymerization in critical areas of light incidence.^{25,26} The formation of a mechanically homogeneous complex in the interaction between post-cement-dentin can be a determining factor in the success of the restorative procedure.²⁷ Due to its wide use, this review included only articles where the fiber posts were luted with resin-based cement seeking to standardize the luting material in order to prevent it from interfering with the results of fiber post removal.

Methodological Issues

Considering the assessment of the risk of methodological bias, all included studies were classified as “high” or “medium” risk of bias. No study reported sample size calculation, which brings uncertainty about the representativeness of the samples. One domain that caused concern was randomization; although only three studies have not done so,^{4,10,20} the randomization process, even in *in vitro* studies, is essential to allow random allocation between different groups, avoiding the risk of distribution affecting the outcome. Many studies did not report whether teeth samples were free of cavities, restorations, which in fact would not be relevant since all studies decoronated the teeth; however, the search for root fractures should be done in view of the fact that it could affect the dental remnant before analysis. Related to the execution of the techniques by a single operator, it is a way to prevent the technical skills of different individuals from affecting the outcome, as shown in an included study of this review.²⁰ There are limitations during blinding of the operator in *in vitro* studies like this; however, it is possible that the analyses are made by blind examiners, reducing the methodological bias.

The efficiency in removing the fiber post is assessed according to the time consumed^{4,8,20} while the effectiveness assessed by four included studies was based on the amount of remnant of the post itself or cement in the root canal walls.^{4,8,19,20} To assess volumetric changes, most of the articles included using micro-CT,^{2,17} a method that makes it possible to obtain precise three-dimensional reconstructions without destroying the sample, allowing the evaluation of any volumetric changes within the root canal, such as dentin thickness, prepared anatomy of the canal and the remaining dentin after post removal, as well as the post-cement-dentin interface.^{2,28} In contrast, one of the studies used flat-panel CT,¹⁹ which also allows obtaining three-dimensional images but has the

advantage of quick analysis as well as allowing the simultaneous evaluation of many samples, while micro-CT explores one tooth at a time.^{19,29}

Arukaslan and Aydemir² also used micro-CT to assess microcracks formed during pin removal, while Çapar et al.¹⁰ used a stereomicroscope. Micro-CT, because it has a higher resolution, can be more accurate in detecting dentinal defects compared to a stereomicroscope, and some cracks or microcracks can form internally and not allow visualization on the root surface through the stereomicroscope.^{30,31}

Analysis of Reported Fiber Post Removal Techniques

A greater ease of removal was alleged to the fiber posts allowing access to the root canal in cases of failure of the post system or endodontic treatment;⁴ in this way, several techniques have been reported in the literature in order to observe this fact.^{2-4,8-11,16-21}

The time taken for the total removal of fiber pins was the outcome most evaluated by the studies included in this review.^{2-4,8,9,11,16,19-21} Manufactured removal kits, in general, proved to be faster during the procedure when compared to ultrasonic inserts.^{2,4,16,19} These manufactured removal kits usually have a pin pilot drill starter, followed by a series of drills that incise the posts, so removal can be achieved in few minutes,^{2,8,32} while the energy generated by ultrasound can be absorbed by the adhesiveness of resinous systems, which may be related to the delay in removal.⁹ However, when removal begins with a drill followed by the use of ultrasonic inserts, this removal is faster than ultrasound or drills used separately.⁹ These worst findings in relation to the ultrasonic insert are also shown in one primary study, where the Er:YAG laser allowed removal in approximately 1:30 minutes, while the ultrasound took almost 10 minutes.³ Although the time factor is clinically relevant, variables such as preservation of the dental structure, safety, and effectiveness could have more impact on the prognosis and the dental remnant to be re-restored.

The remaining amount of tooth structure is a critical factor for sufficient root resistance and long-term tooth retention. Although the procedures for removing the fiber post involve removing the tooth structure,^{2,17} less wear is often expected by the various techniques. In general, the manufactured removal kits managed to generate less wear on the root canal structure when compared to ultrasound¹⁶ or long-shaft round bur, which in turn may have generated greater wear due to the difficulty of keeping the drill parallel to the long axis of the root.¹⁹ In contrast, one study showed that the association of carbide bur with ultrasonic insert generates a greater loss of structure; however, pointing out that this fact occurs due to the intention to remove as much luting agent as possible.⁹

In this sense, preventing the emergence and spread of cracks and microcracks is also a concern when removing posts. The manufactured removal kits appeared to have no significant impact on the initiation and spread of cracks^{2,10} as well as the ultrasonic inserts, which despite generating slightly more flaws than the kit, without significant difference.² The Er:YAG laser also did not cause visible damage to the root surface,³ one of its greatest benefits is its property with a selective target of water and residual monomer molecules of the luting agent, allowing the surrounding dentin to remain intact.^{3,33} However, although it is promising, there was a single study that tested the use of laser for such a procedure, more studies are needed to establish the technology as a safe and viable option.

Regarding the effectiveness of the techniques in removing the fiber post, in the visual analysis of the presence or absence of remaining fibers from the posts or the resin luting agent, the manufactured removal kits appeared to have worse results than the ultrasonic inserts¹⁹ and different types of drills.^{4,8} In contrast, Arukaslan and Aydemir² evaluating the presence of residual cement in the canal walls, found no significant difference between the manufactured removal kits and ultrasound while Abe et al.⁹ showed that the use of drills following the ultrasonic insert reduces this remainder. It is expected that throughout the post removal procedure as well as the following endodontic retreatment, efficient post removal will occur without leaving residues on the root canal walls as well as gutta-percha and endodontic sealers, since such residues can function as a bacterial niche allowing the maintenance of a possible infection.

Ultrasonic inserts may have removed a greater amount of remaining cement due to their heating caused by vibration;⁹ however, the increase in temperature must be carefully evaluated. Procedures that increase the temperature in the root canal can damage dentin structures and periradicular tissues such as the periodontal ligament and alveolar bone.^{3,18} Capriotti et al.¹⁸ used thermographic photographs to evaluate the intraoperative temperature during the removal of the posts with ultrasound and showed excessive heating when used dry, reaching beyond the physiological limits, improving when there was cooling with water. Deeb et al.³ also observed higher temperatures with the use of ultrasonic inserts, increasing from 30 to 38°C while Er:YAG laser maintained the temperatures at 25 to 28°C. What is worrying is that the limit for damage to periradicular structures is an increase of about 10°C for more than 1 minute.^{34,35} As the laser removal consumed less work time, the heat transfer is less keeping almost the same temperature in the entire length of the root canal, while in the ultrasonic inserts, it would dissipate during use reaching higher temperatures in the cervical third and lower in the apical third.³ As mentioned earlier, such results from the Er:YAG laser come from only one included study and have limitations, requiring a learning curve in post-removal using such a procedure.

The studies included in this review show that there are several techniques for removing fiber posts but that there is still no consensus in the literature on which is the best. However, the results tend to show a greater efficiency of the manufactured removal kits, taking into account the working time, while the systems of ultrasonic inserts seem to work better in the removal of remnants of fibers and luting agent. It is worth mentioning that the kits are designed directly for their own fiber post systems, and the clinician is often confronted with unknown systems, leading them to resort to alternative techniques such as ultrasound, laser, or drills.^{2,4} In this way, the establishment of universal manufactured removal kits or techniques that would cover all fiber posts systems becomes hopeful.

One of the limitations of this systematic review may lie in the *in vitro* setting of the evaluation of the fiber posts removal by the included studies, which may differ from clinical results. In addition, one of the major concerns is that, due to large methodological differences, the analyses

and outcomes are based on one or a few studies, making it difficult to extrapolate these results.

Furthermore, this review showed the need for further studies on the fiber post removal of endodontically treated teeth, mainly clinical ones. The choice of the technique can directly infer the

success of the treatment and prognosis of the case, and the literature should point out the risks and benefits of each one, facilitating the decision making of the clinicians.

CONCLUSION

To date, there is no consensus in the literature as to which technique is the best for removing fiber posts luted with resin cements of endodontically treated teeth. However, the results tend to show greater agility in removing fiber posts with manufactured removal kits and the ultrasonic inserts seem to work better in removing the remains of fiber and luting agent.

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