Available online at www.giornaleitalianoendodonzia.it

ORIGINAL ARTICLE/**ARTICOLO ORIGINALE**

Post removal techniques: a systematic review and meta-analysis

Tecniche di rimozione perni: revisione sistematica e meta-analisi

KEYWORDS
Cast Metal Post, Clinical Chair Time, Post-removal, Glass Fiber Post, Ultrasonics

PAROLE CHIAVE
Perni metallici, Tempo clinico alla poltrona, Rimozione perno, Perno in fibra di vetro, Ultrasuoni

Laís Dornelles Bianchini[1]
Bruna Muhlinberg Vetromilla[1*]
Jovito Adiel Skupien[1]
Carlos José Soares[2]
Tatiana Pereira-Cenci[1]

[1]Federal University of Pelotas, Brazil
[2]Federal University of Uberlândia, Brazil

Received 2018, October 17
Accepted 2020, March 12

Abstract

Aim: *This systematic review aimed to answer what is the best way to remove prefabricated metallic, fiber or cast metal posts.*
Methodology: *An electronic search was conducted in Medline and Scopus databases to identify clinical and in vitro studies that assessed post removal techniques from 1950 to October 2018. Tables were generated to summarize the included studies and reports were assessed for bias using the Cochrane risk of bias tool. A meta-analysis was performed to evaluate the force necessary to remove posts (α=5%).*
Results: *Of the 2,951 studies identified in the initial search, 33 were selected. The duration of using ultrasonic vibrations (and the number of surfaces where the vibration was applied) led to less time spent and less force needed to dislodge a metal post. Dentist's expertise (more than 10 years) was also related to easier post removal. The use of adhesive cements resulted in a more difficult protocol for post removal.*
Conclusions: *Although there is need for more consistent results, the data summarized and meta-analysis points toward the use of ultrasonic energy as the first option to remove posts, with best results for metal posts.*

Scopo: *questa revisione sistematica mira a rispondere a quale sia il modo migliore per rimuovere i perni prefabbricati metallici, in fibra o di metallo.*
Metodologia: *è stata condotta una ricerca nei database Medline e Scopus per identificare studi clinici e in vitro che hanno valutato le tecniche di rimozione dei perni dal 1950 a ottobre 2018. Sono state generate tabelle per riassumere gli studi inclusi e le relazioni sono state valutate per bias utilizzando il rischio Cochrane come strumento di giudizio. È stata eseguita una meta-analisi per valutare la forza necessaria per rimuovere i post (α=5%).*
Risultati: *dei 2.951 studi identificati nella ricerca iniziale, 33 sono stati selezionati. La durata dell'utilizzo delle vibrazioni ultrasoniche (e il numero di superfici su cui è stata applicata la vibrazione) ha comportato un minor dispendio di tempo e una minore forza necessaria per spostare un perno metallico. L'esperienza del dentista (più di 10 anni) era anche correlata alla rimozione del perno più facile. L'uso di cementi adesivi ha comportato un protocollo più difficile per la rimozione dei perni.*
Conclusioni: *sebbene siano necessari risultati più coerenti, i dati riepilogati e le meta-analisi indicano l'uso degli strumenti ultrasonici come prima opzione per rimuovere i post, con i migliori risultati per i perni metallici.*

Introduction

The purpose of an intraradicular post is to increase the retention of restorative materials when the remaining dental tissue is not enough to support the treatment performed (1). While post-retained restorations are known to present good survival, with both indirect and direct restorations (2), the need for removal of an intraradicular post may be necessary (3-5), and many methods can assist in this process. The use of an ultrasound device brings the advantage of decreased force to such removal, since their vibrations act in the cement line, causing its rupture (6). How-

Corresponding author
Bruna Muhlinberg Vetromilla | School of Dentistry, Federal University of Pelotas Gonçalves Chaves Street, 457, 96015-560, Pelotas, Rio Grande do Sul | Brazil
bvetromilla@gmail.com

Peer review under responsibility of Società Italiana di Endodonzia
10.32067/GIE.2020.34.01.09

ever, attention should be paid to water-cooling, as there is the risk of reaching a temperature deleterious to adjacent tissues. Another removal method is to drill out the post (depending on the material) with the assistance of diamond, Gates Glidden or Largo burs, or ultrasound cutting tips. In clinical practice, the technique is usually post-dependent. In both techniques, radiographic assessment is important before starting the procedure to avoid unnecessary loss of tooth structure, root perforations or to be sure that no root fracture already exists.

Also, it may be said that the experience of the dentist will influence the success of a post that is to be removed (7, 8). Yet, it is unknown whether there is a best technique to remove a post considering the various types of posts that may be used in clinical practice. Thus, this study aimed to conduct a systematic review to answer if there is a best technique to remove prefabricated metallic, fiber or cast metal posts. The hypothesis tested was that available post removal techniques would result in distinct times of removal and maintenance of sound dental structure.

Materials and Methods

This review followed the guidelines of the Cochrane Handbook for Systematic Reviews of Interventions (9) and the reporting was based on PRISMA (10).

Eligibility criteria

Is ultrasound device better than burs for post removal in endodontic treated teeth, considering time and maintenance of dental structure?

Any in vitro or in vivo study that involved protocols or techniques for dental posts removal were included. Only English-language articles were selected. Studies that did not use post removal techniques were excluded, as well as the clinical case reports and discussions/reviews on the subject.

Information sources and literature search

Searches were performed in electronic databases (Medline and Scopus) to identify all relevant articles published from 1950 to October 2018. The references of articles included in the review were searched, including hand searching, for additional articles. The literature search strategy is available in table 1.

Table 1

Search strategy for the electronic databases

Database	Search strategy
PubMed	((“Tooth, Nonvital”[Mesh] OR “Nonvital Tooth” OR “Tooth, Devitalized” OR “Devitalized Tooth” OR “Tooth, Pulpless” OR “Pulpless Tooth” OR “Teeth, Pulpless” OR “Pulpless Teeth” OR “Teeth, Devitalized” OR “Devitalized Teeth” OR “Teeth, Nonvital” OR “Nonvital Teeth” OR “Teeth, Endodontically-Treated” OR “Endodontically-Treated Teeth” OR “Teeth, Endodontically Treated” OR “Tooth, Endodontically-Treated” OR “Endodontically-Treated Tooth” OR “Tooth, Endodontically Treated”)) AND (“Post and Core Technique”[Mesh] OR “Post-Core Technic” OR “Post-Core Technics” OR “Technic, Post-Core” OR “Technics, Post-Core” OR “Post and Core Technic” OR “Post Technique” OR “Post Techniques” OR “Technique, Post” OR “Techniques, Post” OR “Post Technic” OR “Post Technics” OR “Technic, Post” OR “Technics, Post” OR “Dental Dowel” OR “Dowels, Dental” OR “Dental Dowels” OR “Dowel, Dental”)
Scopus	ALL (“Tooth, Nonvital” OR “Nonvital Tooth” OR “Tooth, Devitalized” OR “Devitalized Tooth” OR “Tooth, Pulpless” OR “Pulpless Tooth” OR “Teeth, Pulpless” OR “Pulpless Teeth” OR “Teeth, Devitalized” OR “Devitalized Teeth” OR “Teeth, Nonvital” OR “Nonvital Teeth” OR “Teeth, Endodontically-Treated” OR “Endodontically-Treated Teeth” OR “Teeth, Endodontically Treated” OR “Tooth, Endodontically-Treated” OR “Endodontically-Treated Tooth” OR “Tooth, Endodontically Treated”) AND ALL (“Post and Core Technique” OR “Post-Core Technic” OR “Post-Core Technics” OR “Technic, Post-Core” OR “Technics, Post-Core” OR “Post and Core Technic” OR “Post Technique” OR “Post Techniques” OR “Technique, Post” OR “Techniques, Post” OR “Post Technic” OR “Post Technics” OR “Technic, Post” OR “Technics, Post” OR “Dental Dowel” OR “Dowels, Dental” OR “Dental Dowels” OR “Dowel, Dental”)

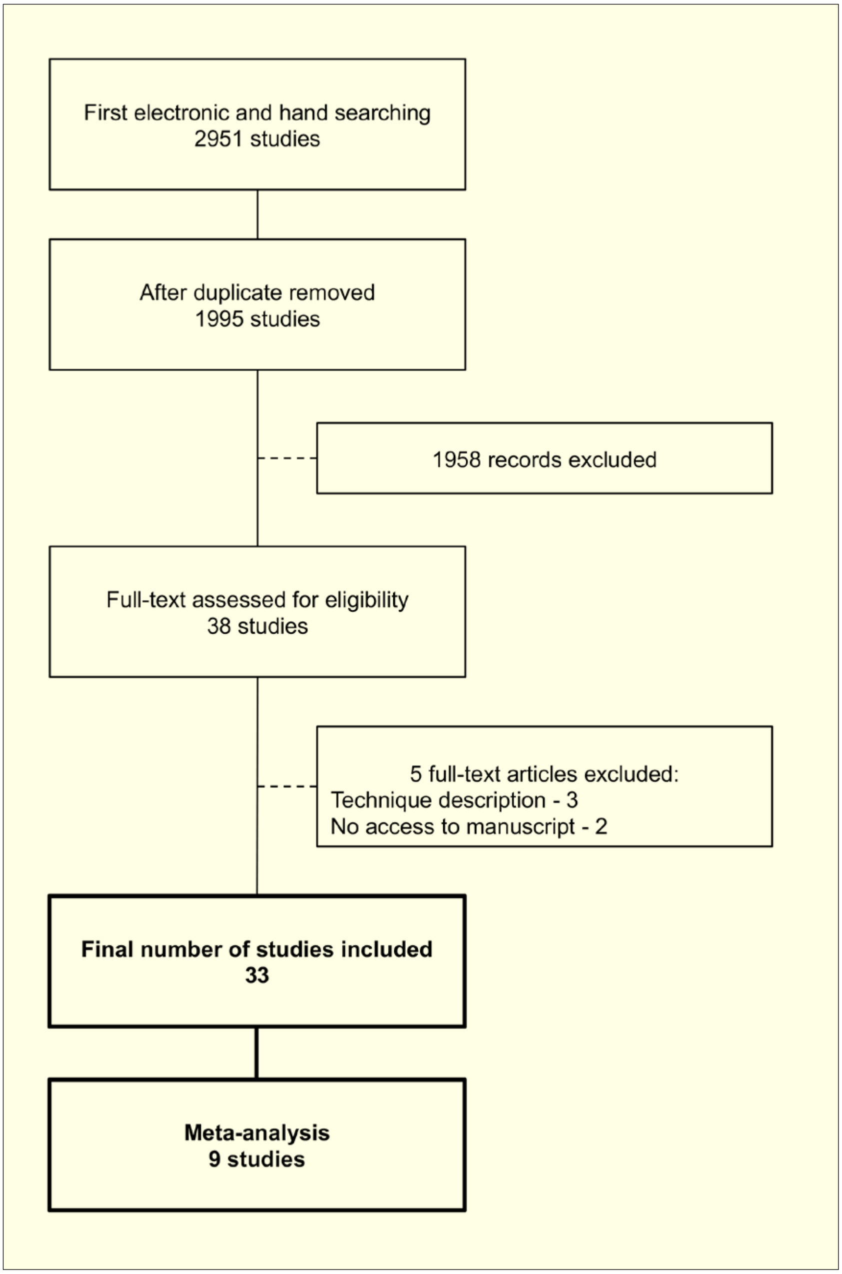


Figure 1
PRISMA flowchart.

Study selection
Literature searches were de-duplicated in the EndNote program. Two independent researchers (LDB and BMV) identified articles by first analyzing titles and abstracts for relevance and presence of the selection criteria listed above. The full-text articles of included and uncertain records were obtained for further eligibility screening by the same two reviewers. Discrepancies in eligibility were resolved through discussion between the two reviewers. In the event of disagreement, the opinion of a third specialist (TPC) was obtained.

Data collection process and data items
Data were collected through Excel (Microsoft Corp, Washington, USA) spreadsheets by the two reviewers, each of them responsible for half of the included studies. A standardized outline was used to extract the main findings of the studies (that is, the results and conclusion) as well as variables as type of technique, type of post and cement were extracted and recorded. The missing data was requested to the authors by e-mail in two attempts. Studies were excluded if there was no reply from the authors or if they did not have the data anymore.

Data synthesis and risk of bias assessment
The estimated effect of pooled data was obtained by comparison of means and was represented by weights between different means ($p<0.05$). The analysis was conducted using Review Manager Software version 5.1 (Copenhagen: The Nordic Cochrane Centre, The Cochrane Collaboration). Also, a qualitative investigation was made with all papers included. Reports of the studies were assessed for bias using the Cochrane risk of bias tool considering the judgment of the blinding of evaluators, presence of a control group, sample size calculation and sample randomization (9).

Results

Study selection and characteristics
The initial literature search yielded 2,951 studies. After duplicates removal and analysis of titles and abstracts, 38 articles were selected to access the full-text and 33 were included in the review (5 excluded for the following reasons: two studies were not found and three were technique descriptions; PRISMA flowchart – figure 1). All studies were in English. The most used technique was ultrasound removal and bur removal. The characteristics of each included study are presented in table 2.

Table 2

Main characteristics of the included studies

Year	Author	Type of substrate	Endodontic treatment	Post type	Aging /storage	Cement	Groups
2017	Graça et al	Molar	Y	Cast post	Humidity at 37°C for 24h	Zinc phosphate	G1: no cavity/no ultrasonic vibration G2: ultrasonic vibration in the coronal portion G3: cavity in the core G4: cavity in the core and ultrasonic inside the cavity
2014	Abe et al	Canine	Y	Glass fiber	Dry light-protect environment for 30 days	Resin cement	G1: diamond bur and largo reamer G2: ultrasonic insert G3: carbide bur and ultrasonic insert
2013	Ebrahimi et al	Canine and PM	Y	Titanium	Water at 37°C for 7 days	Zinc phosphate	G1: post length 5 mm G2: post length 7 mm G3: post length 9 mm
						Glass ionomer	G4: post length 5 mm G5: post length 7 mm G6: post length 9 mm
						Resin cement	G7: post length 5 mm G8: post length 7 mm G9: post length 9 mm
2013	Feiz et al	Premolar	Y	Alloy Metallic	Thermal cycling machine - 5-55°C 500 cycles 20sec of stay | 10sec transfer time	Resin self-etch	G1: No ultrasonic vibration G2: Ultrasonic vibration
						Resin self-adhesive	G3: No ultrasonic vibration G4: Ultrasonic vibration
2013	Scotti et al	Single-Rooted	Y	G1: Fiber post (D.T. Light-Post)	Humidity at 37°C for 24h	Resin cement	G1: Ultrasonic vibration with one unit without refrigeration
				G2: Fiber post (Hi-Rem)			G2: Manufacturer's instructions
2012	Braga et al	Canine	Y	Copper-aluminum alloy	Distilled water at 37°C for 7 days	Zinc phosphate	G1: control (no ultrasonic vibration)
							G2: device tip positioned close to the incisal edge G3: device tip positioned close to the cementation line
2010	Adarsha et al	Canine	Y	Alloy NiCr	Humidity at room temperature for 3 weeks	Glass ionomer	G1: No ultrasonic vibration (control) G2: Ultrasonic vibration without refrigeration G3: Ultrasonic vibration with refrigeration
						Resin cement	G4: No ultrasonic vibration (control) G5: Ultrasonic vibration without refrigeration G6: Ultrasonic vibration with refrigeration
2010	Davis et al	Canine and PM	Y	Metallic	.	Resin cement	G1: common refrigerant spray for 10s G2: common refrigerant spray for 15s G3: common refrigerant spray for 20s G4: water spray for 10s G5: water spray for 15s G6: water spray for 20s G7: air spray for 10s G8: air spray for 15s G9: air spray for 20s
2010	Lipski et al	Incisor	Y	Prefabricated	.	Zinc phosphate	...
2009	Brito-Júnior et al	Premolar	Y	Alloy CuAl	Humidity at 37°C for 7 days	G1: Zinc phosphate	G1/A: Enac
							G1/B: Profi II
							G1/C: Jet Sonic
						G2: Glass ionomer	G2/A: Enac
							G2/B: Profi II
							G2/C: Jet Sonic

Table 2
Main characteristics of the included studies

2009	Garrido et al	Canine	Y	G1 Core: 5mm Post: 1,3mm	Distilled water at 37°C for 7 days	Zinc phosphate	G1/A: Ultrasonic vibration - 5s on each surface
							G1/B: Ultrasonic vibration with intermittent application of the ultrasonic tip, for 10 s on B and L faces alternately, 10 s on M and D faces in the same way and 5 s on the incisal face
				G2 Core: 1,3x5 mm (DxH) | Post: 1,3mm			G2/A: Ultrasonic vibration - 5s on each surface
							G2/B Ultrasonic vibration with intermittent application of the ultrasonic tip, for 10 s on B and L faces alternately, 10 s on M and D faces in the same way and 5 s on the incisal face
				G3 Core: 1,3x3 mm (DxH) | Post: 1,3mm			G3/A: Ultrasonic vibration - 5s on each surface
							G3/B: Ultrasonic vibration with intermittent application of the ultrasonic tip, for 10 s on B and L faces alternately, 10 s on M and D faces in the same way and 5 s on the incisal face
2009	Soares et al	Canine	Y	Alloy NiCr	Humidity at 37°C for 24h	G1: Zinc phosphate	Burs and tapered diamond burs around the post and Ultrasonic Vibration in all surfaces
						G2: Glass ionomer	
						G3: Resin cement	
2008	Braga et al	Canine	Y	G1/A: Stainless Steel	Distilled water at 37°C for 72h	G1: Panavia F 2.0	Enac OE-5 unit and ST09 tips were applied to the incisal portion of the post, perpendicular to the long axis
				G1/B: Titanium			
				G2/A: Stainless Steel		G2: C&B Cement	
				G2/B: Titanium			
2007	Anderson et al	Single-Rooted	Y	G1: Fiber post (D.T. Light-Post)	100% humidity in opaque bottles individually numbered for 7 days	Resin cement (Duo-Link)	A) D.T. Light-Post kit B) Kodex/Tenax drills C) Diamond and Peeso reamer burs
				G2: Fiber post (ParaPost FiberLux)		Resin cement (ParaCem Universal DC)	A) D.T. Light-Post kit B) Kodex/Tenax drills C) Diamond and Peeso reamer burs
2007	Campos et al	Incisor	N	No post	37°C under 100% humidity for 24 h	Zinc phosphate	G1: control (no post)
				CuAlZn alloy			G2: Carbide bur G3: Ultrasound
				PdAg alloy			G4: Carbide bur G5: Ultrasound
2007	Ettrich et al	Not found	Y	Stainless steel	Water bath at 37°C and 100% humidity	Zinc phosphate	G1: no coolant G2: air-cooled G3: water-cooled
2007	Queiroz et al	Single-Rooted bovine	Y	PdAg alloy	Distilled water at 37°C for 72h	Zinc phosphate	G1: with coronal anatomy reproduced G2: without coronal anatomy reproduced
2006	Braga et al	Canine	Y	G1: Glass-Fiber	Distilled water at 37°C for 72h	Resin cement	G1: Instron 4444
				G2: Alloy CuAl			G2: Instron 4444
2005	Braga et al	Canine	Y	Alloy CuAl	Distilled water at 37°C for 72h	Resin cement	G1: Ultrasonic vibration with one unit for 30s on each surface G2: Ultrasonic vibration with one unit for 60s on each surface G3: Ultrasonic vibration with two units for, for 30s on two opposed surfaces at the same time G4: Ultrasonic vibration with two units for, for 60s on two opposed surfaces at the same time G5: No ultrasonic vibration (control)

Table 2
Main characteristics of the included studies

2005	Dominici et al	Incisor	Y	Titanium	100% humidity for 30 days	Zinc phosphate	.
2005	Lindemann et al	Premolar	Y	G1: ParaPost XH (control)	Wrapped in paper towel moistened with water and stored in plastic bags for 24h	ParaPost Cement	G1 Method 1 Ruddle Post Removal System-PRS with refrigeration G1 Method 2 Diamond burs and Ultrasonic vibration
				G2: ParaPost Fiber White			G2 Method 1 Performed according with the manufacturer's instructions G2 Method 2 Diamond burs and Ultrasonic vibration
				G3: Luscent Anchors			G3 Method 1 Performed according with the manufacturer's instructions G3 Method 2 Diamond burs and Ultrasonic vibration
				G4: Aestheti-Plus			G4 Method 1 Performed according with the manufacturer's instructions G4 Method 2 Diamond burs and Ultrasonic vibration
2005	Pečiulienė et al	Single-Rooted	Y	Cast Post	.	G1: Zinc phosphate	MasterPiezon 400 (EMS) with a D4 (EMS) ultrasonic tip
						G2: Modified glass ionomer for resin	
2003	Chandler et al	Canine	N	Titanium	Saline bath at 37°C	Resin cement	G1: Control G2: Trephination G3: Ultrasound
2003	Gesi et al	Anterior	Y	G1: Tapered Fiber	Water for 48h	G1: Dual-Cure	G1/A: Kit RDT G1/B: 1 diamond bur and 1 Largo bur
				G2: Glass-Fiber		G2: Excite DSC and Variolink II	G2/A: Kit RDT G2/B: 1 diamond bur and 1 Largo bur
				G3: Carbon Fiber		G3: Duo-Link Cement	G3/A: Kit RDT G3/B: 1 diamond bur and 1 Largo bur
2003	Hauman et al	Canine	Y	Parapost (SS)	Saline at 37°C for 14 days	Zinc phosphate	G1: vibration G2: no vibration
						Glass ionomer	G3: vibration G4: no vibration
						Resin cement	G5: vibration G6: no vibration
				Parapost (Ti)		Zinc phosphate	G7: vibration
						Glass ionomer	G8: vibration
						Resin cement	G9: no vibration
2002	Castrisos et al	Single-Rooted	Y	Non-precious alloy	.	Zinc phosphate	G1: 1 mm of dentine thickness G2: 2 mm of dentine thickness
2002	Dixon et al	Canine	Y	Alloy Stainless Steel	Natural water at room temperature for at least 2 months	Zinc phosphate	G1: Instron 444 G2: Spartan Ultrasonic G3: Enac Ultrasonic

Table 2
Main characteristics of the included studies

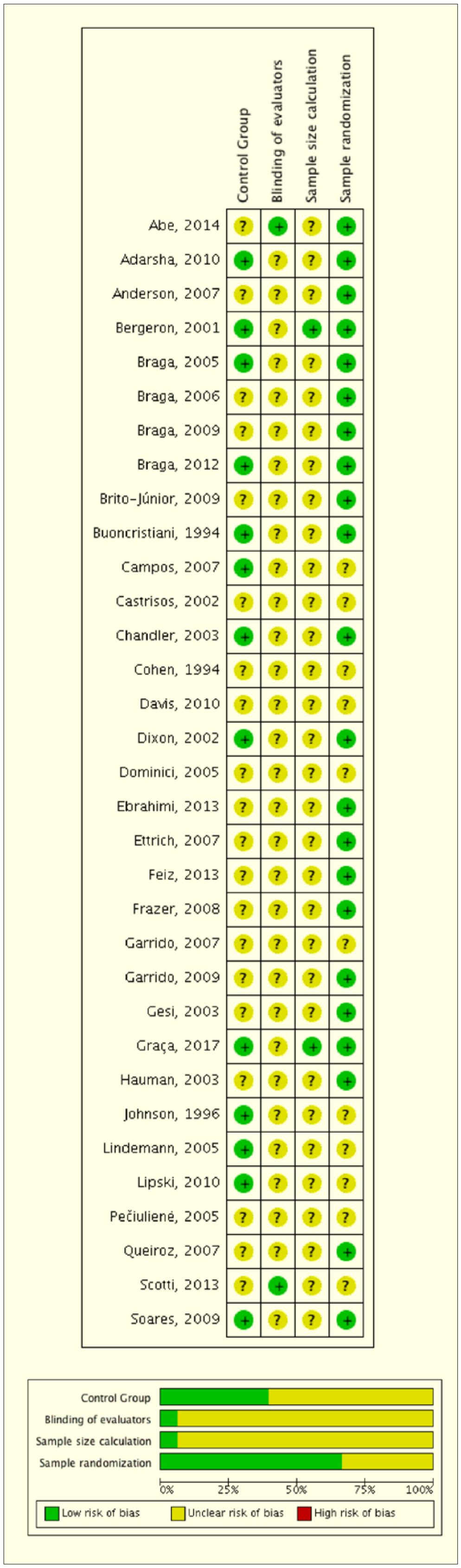
2001	Bergeron et al	Canine	Y	Titanium	37°C under 100% humidity for 14 days	Zinc phosphate	G1: vibration and Root's 821 Elite Sealer G2: no vibration and Root's 821 Elite Sealer G3: vibration and AH26 Sealer G4: no vibration and AH26 Sealer
						Resin cement	G5: vibration and Root's 821 Elite Sealer G6: no vibration and Root's 821 Elite Sealer G7: vibration and AH26 Sealer G8: no vibration and AH26 Sealer
1996	Johnson	Premolar	Y	Parapost (SS)	37°C and 100% humidity for 30 days	Zinc phosphate	G1: Control (no vibration) G2: Ultrasonic for 4 minutes
							G3: Ultrasonic for 12 minutes G4: Ultrasonic for 16 minutes
1994	Buoncristiani	Single-rooted	Y	Titanium	100% humidity for 24 h	Zinc phosphate	G1: Control (Cavitron ultrasonic) G2: Neosonic ultrasonic G3: Enac ultrasonic G4: Micro mega sonic selaer G5: Densonic sonic sealer

Risk of bias of the included studies
From the 33 studies included, almost all presented unclear risk of bias (figure 2). The parameters considered in the analysis were the presence of a control group, blinding of evaluators, sample size calculation and sample randomization.

Results of individual studies and synthesis of results
Two types of outcomes were extracted from the 33 papers selected: time of post removal (11-21) and force required for post dislodgment or removal. Due to different methodologies and materials employed in those papers, a meta-analysis was only possible to be done with nine studies regarding the force needed to dislodge the intraradicular posts (11, 22-29). The main reasons for the impossibility of gathering data in the meta-analysis were varying types of posts, cements (resin-based, zinc phosphate, glass-ionomer-based) but especially various techniques employed for post removal as ultrasonic vibration with totally different protocols, use of kits for removal or use of diamonds/largo burs. Also, three papers were excluded and could not be included in the meta-analysis as it was impossible to extract the data (data presented in graphs – even after contact with the authors to obtain raw data or not enough data available to run the analysis) (18,30,31). The analysis using a random-effect model showed that the necessary force to remove prefabricated and cast metal posts is decreased in 64.03 N (53.95-74.12; $p<0.00001$, figure 3) when using ultrasonic vibration.

Descriptive analysis
Due to heterogeneous datasets, a descriptive analysis was the only option to describe the results of the other included studies. Not only the type of post and type of luting material were different among the included studies, but also the intervention method to evaluate post removal was also distinct. Even when ultrasonic vibration was assessed, the duration of ultrasonic vibration used (6, 16, 22, 32) and the use or not of water spray (11, 16, 33, 34) were also evaluated, leading to various scenarios that impaired the analysis. Still, it was possible to observe that the longer the duration of using ultrasonic vibrations (as well as the number of surfaces where the vibration was applied), the lower the time or the force needed to dislodge the post.
The influence of the dentist's expertise was also evaluated. Irrespective of the technique used to remove the post, a dentist with more than ten years of expertise in endodontics removed the post in less

Figure 2
Assessment of risk of bias of included studies.



time compared with an undergraduate student (20). Still, concerning the time spent to remove the post, a comparison regarding the type of material used for cementation was possible. Three studies found that posts cemented with zinc phosphate took less time to be removed when compared to glass ionomer cement irrespective of the method used (14, 19, 35). However, when compared with resin-based cement, both presented lower time needed to remove the post (21, 31, 35). Besides, regarding the force necessary to dislodge the post, one study found no difference between zinc phosphate, glass ionomer and resin-based cements (25), while another study evaluated resin-based and glass ionomer-based cement and concluded that it seems to be technique-dependent (11). One important clinical issue is the removal of a coronal portion of the post until the cement line is visualized, which could clinically help post removal; however, only two studies reported this issue in the methodology (14, 27).
As for the material of the post, one study considered time needed to remove different types of posts and found that titanium posts took more time to be removed than fiber posts (31). Three studies compared post resistance. Glass fiber posts required more force to be removed compared to cast post (13) while titanium and glass fiber posts removal were dependent on the cement brand used (22). When titanium and stainless steel posts were compared, no difference was found (25).

Discussion

This is the first systematic review comparing various techniques available to remove intraradicular posts and it has shown that time spent to remove a post using an ultrasound device is statistically significantly lower compared to other techniques for cast metal posts.
It seems that ultrasonic energy would be helpful for fiber post removal, but the evidence is not as strong as for cast metal posts. Besides, when considering post removal, a series of actions should be care-

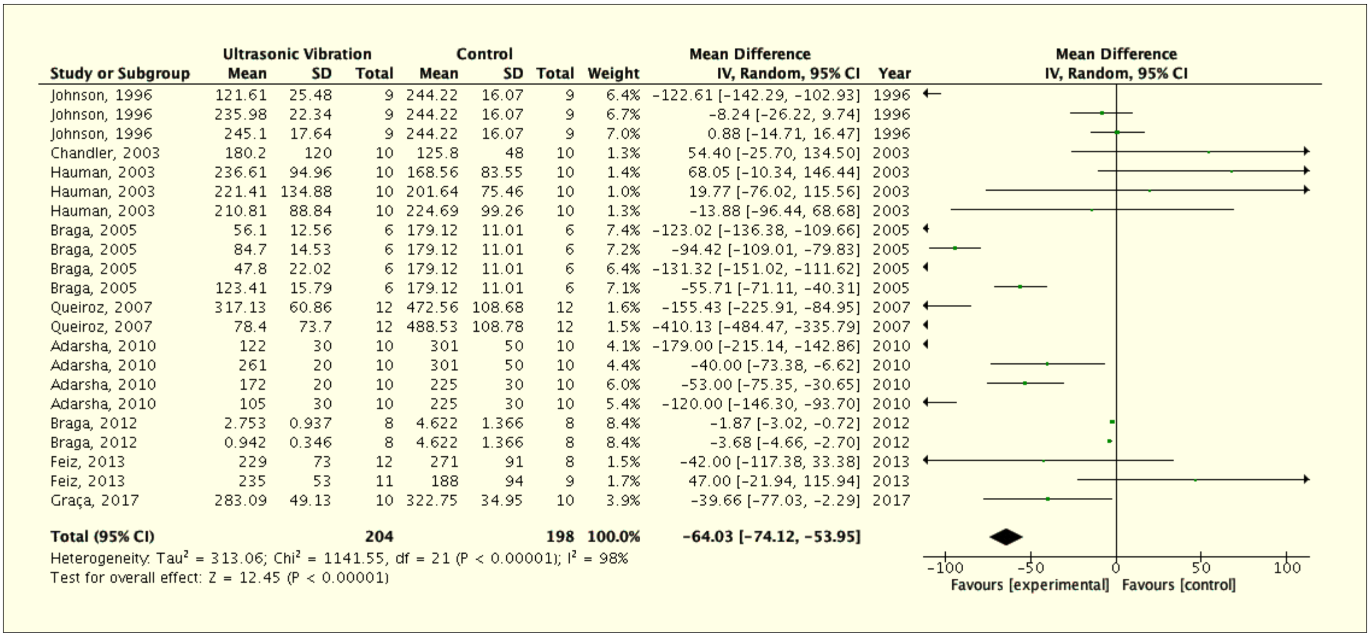


Figure 3
Results of meta-analysis. Best results are shown for ultrasonic vibration group (p<0.00001).

fully planned to avoid iatrogenic perforations or root fractures, including an X-ray. Techniques as use of trephines, hemostats or forceps are less used because of disadvantages as the procedure takes longer time, it removes more sound dental structure, and there is a need of the presence of a coronal structure for the apprehension of the instrument. The use of these specific devices to break the cement and pull out the post is only possible when a passive post has been used as there is a risk of a root fracture in active posts. These techniques, although reported in the literature, were not included in our study, as force is impossible to be measured, but also because no reports were found comparing those techniques.

When drilling out a post with diamond burs, there is sound dental structure removal, but this is lower when compared to the other technique cited above and is a feasible option to be used together with ultrasonic devices. On that situation, there is a difference between metallic and glass fiber posts removal. For the former, the idea is to open space for the post to be dislodged. Also, the technique is to diminish the metallic post diameter and height to expose the cement. Yet, for the fiber posts the technique is intended to drill the post completely.

Ultrasonic energy is effective when used to remove metal posts, as these materials are rigid and present high elastic moduli, allowing vibrations to be conducted along the post, reducing the necessary force for removal. On the other hand, for fiber posts, the use of this technique still remains uncertain, as there is not enough information to draw definitive conclusions. The use of ultrasonic devices present the advantage of less chair time, although it presents higher cost and possibility of generating dentin micro cracks. When the use of ultrasonic device is not enough to dislodge the post, drills may be additionally used for final removal (13, 19, 21, 29). However, when considering glass fiber posts – and their low elastic modulus – the scenario may be different. Glass fiber posts are more difficult to be removed with ultrasonic devices, as not only the elastic modulus will negatively influence on the breaking of cement, but the cement itself is usually a resin-based cement, which neutralizes vibrations, absorbing the energy (21). Thus, it seems reasonable to indicate post drilling when a fiber post is to be removed.

Regarding the bonding agent, zinc phosphate took less time to be removed when compared to glass ionomer cement irrespective of the method used (14, 19, 35). When comparing these two cements with resin-based cements, both demonstrated lower time for removal (21, 31, 35). Historically, cast metal posts were cemented with zinc phosphate, which allows easy rupture when ultrasonic energy is used. Resin-based cements available are used to lute any type of post and the difficulty on its removal is possibly due to a better dentin union when compared to zinc phosphate and glass ionomer cements. In contrast, some authors report that the heat of ultrasonic devices would decrease adhesive characteristics of resin-based cements, leading to similar results when compared to the other cements (36).

The impossibility of comparing time difference to remove different post types and cements is one of the limitations from the present study, and it is justified by the high heterogeneity of the present data. There is need of standardized studies, even if they are in vitro. Details as sample size calculation, randomization, use of control/comparison group, measurement of time for post removal, blinding of the operator, when possible, are usually reported in clinical trials and should be present also in in vitro studies. Specifically, the authors must choose a technique and vary the type of cement and type of post or other variables, as presence or not of water-cooling. Considering that cast metal posts, glass fiber posts and resin cements are the most commonly selected materials (37), those must be selected for future studies.

In the present review, no conclusive advice can be given for fiber posts removal in clinical practice, due to limited data regarding it or the lack of standardized studies with this type of post. In addition, if a post is cemented with resin-based cement, glass ionomer and zinc phosphate, the bond strength of the first is higher than the others (36), leading us to believe that if there is a best technique to remove a post cemented with resin cement, probably it will be the best for the other types of cements. Considering the increased use of fiber posts, fur-

References

1. *Schwartz RS, Robbins JW. Post placement and restoration of endodontically treated teeth: a literature review. J Endod 2004;30:289-301.*
2. *Skupien JA, Cenci MS, Opdam NJ, Kreulen CM, Huysmans MC, Pereira-Cenci T. Crown vs. composite for post-retained restorations: A randomized clinical trial. J Dent 2016;48:34-9.*
3. *Abe FC, Bueno CE, De Martin AS, Davini F, Cunha RS. Efficiency and effectiveness evaluation of three glass fiber post removal techniques using dental structure wear assessment method. Indian J Dent Res 2014;25:576-9.*
4. *Goodacre CJ, Bernal G, Rungcharassaeng K, Kan JY. Clinical complications in fixed prosthodontics. J Prosthet Dent 2003;90:31-41.*
5. *Ng YL, Mann V, Gulabivala K. Outcome of secondary root canal treatment: a systematic review of the literature. Int Endod J 2008;41:1026-46.*
6. *Garrido AD, Oliveira AG, Osorio JE, Silva-Sousa YT, Sousa-Neto MD. Evaluation of several protocols for the application of ultrasound during the removal of cast intraradicular posts cemented with zinc phosphate cement. Int Endod J 2009;42:609-13.*
7. *Rollings S, Stevenson B, Ricketts D. Posts–when it all goes wrong! Part 1: case assessment and management options. Dent Update 2013;40:82-4,6-8,90-1.*
8. *Rollings S, Stevenson B, Ricketts D. Posts–when it all goes wrong! Part 2: post removal techniques. Dent Update 2013;40:166-8,70-2,75-8.*
9. *Higgins JP, Altman DG, Gotzsche PC et al. The Cochrane Collaboration's tool for assessing risk of bias in randomised trials. BMJ 2011;343:d5928.*
10. *Moher D, Liberati A, Tetzlaff J, Altman DG, Group P. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. BMJ 2009;339:b2535.*
11. *Adarsha MS, Lata DA. Influence of ultrasound, with and without water spray cooling, on removal of posts cemented with resin or glass ionomer cements: An in-vitro study. J Conserv Dent 2010;13:119-23.*
12. *Anderson GC, Perdigao J, Hodges JS, Bowles WR. Efficiency and effectiveness of fiber post removal using 3 techniques. Quintessence Int 2007;38:663-70.*
13. *Braga NM, Paulino SM, Alfredo E, Sousa-Neto MD, Vansan LP. Removal resistance of glass-fiber and metallic cast posts with different lengths. J Oral Sci 2006;48:15-20.*
14. *Brito Jr M, Soares JA, Santos SM, Camilo CC, Moreira Jr G. Comparison of the time required for removal of intraradicular cast posts using two Brazilian ultrasound devices. Braz Oral Res 2009;23:17-22.*
15. *Dixon EB, Kaczkowski PJ, Nicholls JI, Harrington GW. Comparison of two ultrasonic instruments for post removal. J Endod 2002;28:111-5.*
16. *Garrido AD, Fonseca TS, Silva-Sousa YT, Alfredo E, Sousa-Neto MD. Evaluation of root external temperature during the application of ultrasound in removal of intraradicular posts. Gen Dent 2007;55:121-4.*
17. *Gesi A, Magnolfi S, Goracci C, Ferrari M. Comparison of two techniques for removing fiber posts. J Endod 2003;29:580-2.*
18. *Lindemann M, Yaman P, Dennison JB, Herrero AA. Comparison of the efficiency and effectiveness of various techniques for removal of fiber posts. J Endod 2005;31:520-2.*

ther research must be conducted for this material. Also, non-destructive techniques as MicroCT and cone beam could be helpful to measure the amount of dentin lost during the removal process.

Conclusions

Based on the findings from the present study, the use of an ultrasonic device seems to be the best technique when removing metal posts, although it seems less predictable for removing non-metal posts. Type of cement, post design, and length are important co-factors. More studies are necessary to draw more precise conclusions.

Clinical Relevance

When there is a need for removal of an intraradicular post, the use of an ultrasonic device is the best technique for metal post, although it is less predictable for non-metal posts. Post design, length, and type of cement are co-factors and should be considered as well.

Conflict of Interest

The authors deny any conflicts of interest.

Acknowledgments

This study was financed in part by Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brazil (CAPES) – Finance Code 001, #88882. 346903/2019-01. TPC is partially funded by the National Council for Scientific and Technological Development (CNPq - Brazil) and FAPERGS - PRONEX #16/2551-0000471-4. The funders had no role in the study design, data collection, and analysis, decision to publish or preparation of the manuscript.

References

19. *Peciuliene V, Rimkuviene J, Maneliene R, Pletkus R. Factors influencing the removal of posts. Stomatologija 2005;7:21-3.*
20. *Scotti N, Bergantin E, Alovisi M, Pasqualini D, Berutti E. Evaluation of a simplified fiber post removal system. J Endod 2013;39:1431-4.*
21. *Soares JA, Brito-Junior M, Fonseca DR et al. Influence of luting agents on time required for cast post removal by ultrasound: an in vitro study. J Appl Oral Sci 2009;17:145-9.*
22. *Braga NM, Resende LM, Vasconcellos WA, Paulino SM, Sousa-Neto MD. Comparative study of the effect of ultrasound on the removal of intracanal posts. Gen Dent 2009;57:492-5.*
23. *Braga NM, Silva JM, Carvalho-Junior JR, Ferreira RC, Saquy PC, Brito-Junior M. Comparison of different ultrasonic vibration modes for post removal. Braz Dent J 2012;23:49-53.*
24. *Chandler NP, Qualtrough AJ, Purton DG. Comparison of two methods for the removal of root canal posts. Quintessence Int 2003;34:534-6.*
25. *Hauman CH, Chandler NP, Purton DG. Factors influencing the removal of posts. Int Endod J 2003;36:687-90.*
26. *Johnson WT, Leary JM, Boyer DB. Effect of ultrasonic vibration on post removal in extracted human premolar teeth. J Endod 1996;22:487-8.*
27. *Queiroz EC, Menezes MS, Biffi JC, Soares CJ. Influence of the shape core on custom cast dowel and core removal by ultrasonic energy. J Oral Rehabil 2007;34:463-7.*
28. *Feiz A, Barekatain B, Naseri R, Zarezadeh H, Askari N, Nasiri S. The influence of ultrasound on removal of prefabricated metal post cemented with different resin cements. Dent Res J (Isfahan) 2013;10:760-3.*
29. *Graça IAA, Sponchiado Júnior EC, Marques AAF, de Moura Martins L, Garrido ÂDB. Assessment of a Cavity to Optimize Ultrasonic Efficiency to Remove Intraradicular Posts. J Endod 2017;43(8):1350-1353.*
30. *Cohen BI, Pagnillo M, Condos S, Musikant BL, Deutsch AS. Post removal using a thick-walled hollow tube post design. Oral Health 1994;84:15-8,21-2.*
31. *Frazer RQ, Kovarik RE, Chance KB & Mitchell RJ. Removal time of fiber posts versus titanium posts. Am J Dent 2008;21(3):175-178.*
32. *Dominici JT, Clark S, Scheetz J, Eleazer PD. Analysis of heat generation using ultrasonic vibration for post removal. J Endod 2005;31:301-3.*
33. *Davis S, Gluskin AH, Livingood PM, Chambers DW. Analysis of temperature rise and the use of coolants in the dissipation of ultrasonic heat buildup during post removal. J Endod 2010;36:1892-6.*
34. *Ettrich CA, Labossiere PE, Pitts DL, Johnson JD. An investigation of the heat induced during ultrasonic post removal. J Endod 2007;33:1222-6.*
35. *Ebrahimi SF, Shadman N, Nasery EB, Sadeghian F. Effect of polymerization mode of two adhesive systems on push-out bond strength of fiber post to different regions of root canal dentin. Dent Res J (Isfahan) 2014;11:32-8.*
36. *Hagge MS, Wong RD, Lindemuth JS. Retention strengths of five luting cements on prefabricated dowels after root canal obturation with a zinc oxide/eugenol sealer: 1. Dowel space preparation/cementation at one week after obturation. J Prosthodont 2002;11:168-75.*
37. *Sarkis-Onofre R, Pereira-Cenci T, Opdam NJ, Demarco FF. Preference for using posts to restore endodontically treated teeth: findings from a survey with dentists. Braz Oral Res 2015;29:1-6.*