Techniques for removing root canal posts – an vitro study

Técnicas para remoção de pinos intrarradiculares – um estudo in vitro

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Resumo

Objetivo: O objetivo deste estudo foi responder qual é a melhor técnica para remoção de pinos de fibra de vidro e pinos metálicos fundidos considerando tempo, preservação da estrutura dentária e custos. Métodos: Foi realizado um estudo in vitro, randomizado e cego. Sessenta dentes tratados endodonticamente foram randomizados em dois grupos de acordo com o tipo de pino. Uma segunda randomização foi realizada para cada tipo de técnica de remoção (ultrassom, broca ou combinada; n=10). One-way ANOVA foi usado para comparar o tempo de remoção do pino, teste t pareado comparou a quantidade de estrutura dentária removida e Kruskal Wallis seguido pelo teste post hoc de Mann-Whitney foram usados para análise de custo (P = 0,05). Resultados: Não houve diferença no tempo de remoção do pino considerando o tipo ou técnica do pino (P=0,630). A perda média de estrutura dentária na região cervical foi superior a 30% quando apenas uma ponta diamantada foi usada para remover pino de fibra de vidro (P<0,00001) e pino metálico fundido (P=0,008). Conclusão: De acordo com os resultados deste estudo, podemos concluir que a seleção da técnica de remoção dependerá da habilidade do operador, e sempre ocorrerá alguma perda de estrutura dentária, embora seja esperada uma perda maior quando apenas pontas diamantadas são usadas para este fim.

Palavras-chave: Técnica de Postes e Núcleos, Custos e Análise de Custos, Pós-remoção, Fundição de Fibra de Vidro, Técnicas In Vitro

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Introduction

Endodontically treated teeth restorations can be complex when there is extensive loss of tooth structure[1]. Root canal posts are used to improve retention, promote support[2,3] and therefore influence tooth survival[2,4]. Cast metal posts are still the gold standard when there are no remaining dentin coronal walls whilst metal posts have shown high survival rates after 10 years, and the types of posts used did not influence endodontic treatment outcomes when a full crown restoration was employed[5,6]. Clinical trials revealed high survival rates after more than 5 years with a failure rate of 1.5% [4]. Glass fiber posts are also used due to their compatible biomechanical and aesthetic properties compared to that of dentin[7]. There is currently a point of discussion on which type of post is better to decrease the possibility of root fractures[8,9].

Although the use of these devices presents a high success rate, failures may occur, or periapical pathologies might lead to the need for endodontic retreatment and their removal may be necessary[6]. The removal of root canal posts can be difficult because the adhesive technique of resin cement is considered challenging[7], whereas cast metal posts are known to be easy to remove but, in most cases, it is necessary to widen the post space and therefore remove tooth structure for its removal. Amongst the techniques and devices that help and make safe, the post-removal is the use of ultrasound tips, which act on the cementation line, allowing its rupture and consequently less force during post-removal[7,10]. The use of ultrasound tip is well established when zinc phosphate cement is used for cast metal post cementation. However, with the increased use of glass fiber posts, the use of resin cement for almost all types of posts has also increased. Thus, the techniques described above for removing cast metal posts may not apply to these cement or other types of posts. Another well-known removal method is the use of diamond burs and/or the combination of different techniques[11].

The choice of technique may depend on the type of post and cement used. Glass fiber posts present a low modulus of elasticity, and resin cement may absorb the energy of the ultrasound tip, making the cement difficult to break. The best removal technique results from the consideration of all difficulties imposed both by posts and cement. Also, a clinical trial to test which technique would be best to remove root canal post and cement would be unethical, and there are currently no standardized studies that allow the conclusion of which is the most effective and efficient removal technique for root canal posts. Thus, the aim of this study was to perform an in vitro study to answer which is the best technique to remove glass fiber and cast metal posts considering time, preservation of tooth structure, and cost. The hypothesis tested was that the use of ultrasound tip would take less time, preserve more tooth structure, and be less costly when compared with other techniques.

Methodology

This study was a randomized and blind (outcome assessment) in vitro study. The type of post (cast metal or glass fiber) and removal technique (ultrasound tip, diamond bur, or combination of both) were the factors under study. This study was approved by the Local Research Ethics

Committee (#2332011). Sixty human uniradicular teeth were selected, endodontically treated, and randomized according to the type of post and post-removal technique. The outcomes were the time taken to remove the post, the amount of tooth structure removed in the cervical area, and the cost of the procedures.

The sample size calculation was based on in vitro studies evaluating post-removal techniques[3,12] considering a power of 80% and the average, a 5% alpha, and a difference of 22% among groups with a total of 60 teeth. Sixty uniradicular teeth (canines and premolars) were pre-selected according to their shape and root length and stored in distilled water. These teeth were sectioned 2 mm above the cementoenamel junction with a diamond disk under constant cooling. Teeth were maintained humid during all steps. Two independent researchers performed endodontic treatment procedures, manufacturing, and cementation of root canal posts and their removal. Root canals were prepared at the actual length of the tooth using hand files #10 and #15 (Dentsply/Maillefer) and Logic I Rotary Files (Easy). First, cervical third exploration (apparent length of 4 mm) with hand files #10 and #15 followed by rotary file number 30.10 the cervical third was prepared. Again, with files #10 and #15 exploration of the apical third and actual length of the teeth were taken. With rotary files number 15.05, 25.05, 35.05, and 45.05 the apical thirds of the teeth were prepared according to the diameter of the foramen. During instrumentation, root canals were irrigated with 20ml of 2.5% NaOCl and 5ml of EDTA. The stirring protocol of the auxiliary chemical substance EDTA trisodium was performed using an ultrasound device (Gnatus Company, Ribeirão Preto, Brazil) using the G1 tip and Irrisonic E1 insert (Helse Ultrasonic), programmed at the lowest power (10%). The insert was inserted into the root canals 2 mm short of the CRT, with 3 cycles of agitation activated for 20 seconds in each cycle, with oscillating movements without touching the root canal walls. The canals were filled with gutta-percha (Dentsply/Maillefer) calibrated with a gauge ruler according to the final diameter of each dental element preparation and endodontic cement Sealer 26 (Dentsply), using vertical condensation technique. Samples remained in distilled water at 37°C for seven days[13,14].

Next, the second researcher included the samples in standardized PVC pipes filled with self-curing acrylic resin. Root canals were prepared for the prosthetic space, using Largo #3 drills with the active tip of 1.1mm (Dentsply/Maillefer) until two-thirds of the length of all teeth was reached. The root canals were cleaned with 97% ethanol and dried with absorbent paper cones (Dentsply/Maillefer). Alcohol was used as a final irrigant, acting by drying the cannals, reducing surface tension[15]. The samples were randomly divided using a spreadsheet Excel into six groups (n=10) according to the type of post (cast metal or glass fiber) and removal technique used (ultrasound tip, diamond bur, or combination). Subsequently, the root canal posts were made and cemented. The cast metal post was made by molding the root canals with chemically activated pattern resin and molding post (Pinjet, Angelus), the core was already waxed onto them, and cast in CoCr alloy. Glass fiber posts (#2 DC, FGM) were used for all teeth in the fiber post groups and composite cores were bonded to the fiber post with composite resin (Filtek Z350 XT, 3MESPE). For the standardization of the groups, cores were made with the same measurements after conditioning with phosphoric acid (Acid Gel, Villevie) and application of a light-curing adhesive system (Adper

Single Bond, 3MESPE). Both cast and glass fiber posts were cemented with self-adhesive resin cement (RelyX U200, 3MESPE) according to the manufacturer's instructions. For the cementation, cast metal and glass fiber posts were cleansed with 70% alcohol. The root canal was washed with water and then lightly air-dried. A glass fiber post received a silane coating (Maquira) and was air-dried after 1 min. A Centrix syringe (Maquira) was used to introduce the cement into the root canals and coat their walls. After placing the posts into the root canals, six minutes under digital pressure were followed by light curing (Radii-Cal, SDI) for 40 s on each surface (Light intensity: 1200mW/cm²; Wavelength: 440 nm – 480 nm). Both types of posts were prepared using diamond burs to achieve a regular chamfer. Thus, there were 30 teeth with glass fiber posts and 30 teeth with cast metal posts each subdivided into three groups for each of the three removal techniques.

For the ultrasound tip group, posts received ultrasonic vibrations for as long as necessary to loosen the post, with the instrument set to maximum power under refrigeration (GJSB, Scaler Gold Line, Essence Dental VH). To transfer vibrations to the specimens, the instrument tip was placed on the buccal, lingual, mesial, and distal surface between the post/tooth interface (on the cement surface), these retainers received ultrasonic vibrations for 4 min (Gnatus Company, Ribeirão Preto, Brazil), with the device adjusted to maximum power and with cooling for 30 s on each face, using the smallest of the 3 tips, Irrisonic E1 insert (Helse Ultrasonic). For the diamond bur group, #1012 spherical diamond burs (KG Sorensen) were used to expose the posts, the diamond bur was positioned on the cement line to perform the removal of cement of the post/tooth interface until the post was loosened and wide drills were used to remove remnants from the post and resin cement inside the root canals. In the combination group, diamond burs and wide drills were used to create adequate space for the ultrasonic energy tip to assess the post/tooth interface, and those used to break the existing interface and vibrate the devices. For all groups, hemostatic forceps were used to assist in the removal of the posts and for the application of tensile force. The time required to remove the posts was considered from the beginning of the post-removal process until complete removal.

Evaluation of the remaining tooth structure after complete removal of root canal posts was performed using periapical radiographs. To perform the radiographs, the teeth were fixed in an acrylic resin structure, and the set was placed in the positioner for X-ray exposure. An initial radiograph was performed to assess the conformation of the dental elements and to perform endodontic treatment. Subsequently, a new radiographic examination was performed after endodontic treatment before cementation. A third radiograph was performed after the removal of the root canal post using a standardized technique. Measurements were considered as the difference between the last and the second radiograph in the cervical area of the teeth (3 mm below the cementoenamel junction), where there is usually more tooth structure loss.

The computer program Meazure was used to perform the linear measurement from one point on the buccal interface to another point on the lingual interface and from that value, reducing the measurement of the root canal lumen (performed in the same way), obtaining the remaining dentin before post cementation. The same measurements were taken after the removal of the posts;

however, the measurement of the root canal lumen increased where the removal of the tooth structure occurred.

The costs were made for each technique considering only direct medical costs, comprising all materials and consumables necessary for the completion of a technique and a value established for a clinical appointment based on the catalog of the current Public Health System. The clinical time was calculated individually considering the post-removal time for each tooth. Materials and consumables costs were accrued from the amount of material (quantity) and its purchase costs based on the country catalogs. Non-medical costs (structure costs, productive inputs etc.) and indirect (opportunity) costs were not accounted for since they were assumed to be similar among treatments.

Data were statistically analyzed using a significance level of 5%. Analyses for the time required for post-removal were performed by one-way ANOVA and for the analysis of the tooth structure loss, a paired t-test was used considering the loss of the teeth in the same group. Due to the heterogeneous distribution, Kruskal Wallis followed by Mann-Whitney *post hoc* was performed to compare costs.

Results

Table 1 presents the results for time elapsed in each removal technique. There were no statistically significant differences among groups considering the time spent to remove the post (*P*=0.630). Still, glass fiber posts took the longest time to be removed when using ultrasound tip only (7.4 ±3.9 min), while cast metal posts with ultrasound were the fastest to remove (4.5 ±0.8 min).

Table 1. Time for post-removal in each group (in minutes).

Type of post	Technique	Time for removal
Glass fiber	Ultrasound tip	7.4 ±3.9
	Diamond Bur	7.3 ±4.5
	Combination	5.8 ±3.6
Cast metal	Ultrasound tip	4.5 ±0.8
	Diamond Bur	5.5 ±1.3
	Combination	5.0 ±0.7

Values are mean ±SD. There were no statistically significant differences between the groups; one-way ANOVA (*P*=0.630).

Table 2 shows the mean tooth structure measurements before and after the removal of the post and the percentage of mean loss for each group. The mean loss of structure in the cervical area was more than 36.9% when only a diamond bur was used to remove the glass fiber post. For the cast metal post, although there was a statistically significant difference before and after removal

(*P*=0.008), around 10.2% of tooth loss was observed using ultrassound tip, the lowest of all groups. All groups presented statistically significant differences in tooth structure loss after post-removal.

Table 2. Measurement of tooth structure (mm) before and after post-removal and percentage of tooth loss.

Group	Remaining before	Remaining after	% Loss	*P*-value
Glass fiber with ultrasound tip	5.7 ±0.9	4.6 ±0.7	17.5 ±11.3	*P*=0.00139
Glass fiber with diamond bur	5.3 ±0.9	3.4 ±0.8	36.9 ±11.1	*P*<0.00001
Glass fiber combination	5.3 ±1.0	3.7 ±1.3	29.3 ±20.5	*P*=0.00158
Cast metal with ultrasound tip	5.4 ±0.8	4.9 ±1.1	10.2 ±10.2	*P*=0.00824
Cast metal with diamond bur	5.8 ±0.6	4.1 ±1.3	29.5 ±19.0	*P*=0.00037
Cast metal combination	5.4 ±0.5	4.1 ±0.9	23.3 ±17.6	*P*=0.00309

Values are mean ± SD. There were statistically significant differences in the loss of tooth structure during the procedure in each group (paired t-test).

There were nine post fractures in the glass fiber posts and these posts were removed with diamond burs once the fracture occurred. Of these fractures, four occurred in the ultrasound tip group, four in the diamond bur group, and one in the combination group. There were also two root fractures in the cast metal posts, one in the ultrasound group and another in the combination group. Although those root fractures occurred, all cast metal posts were completely removed.

The costs of materials used to remove posts are detailed in Table 3. The costs were calculated for each tooth in each technique, considering the time taken to remove the post, being: Cast metal post ultrasound (US$ 5.76 ± 0.13); Cast metal post bur (US$5.51 ± 0.21); Cast metal post combination (US$7.02 ± 0.12); Glass fiber post ultrasound (US$ 6.23 ± 0.65); Glass fiber post bur $5.97 (0.90); Glass fiber post combination (US$7.15 ± 0.60).

Table 3. Costs of materials.

Material	Cost (US$)	Number of applications	Amount used (per session)	Total (US$)
Gloves	20.99	50	2	0.82
Saliva ejector	5.75	40	1	0.14
Dental bib	12.90	100	1	0.12
Disposable nurse cap	7.75	100	1	0.07
Mask	6.49	1	1	0.12
Cotton roll	1.60	100	2	0.02
Radiographic film	159.00	150	2	2.12
Ultrasound tip[a,c]	160.00	100	1	1.60

Diamond bur[b,c]	11.60	20	1	0.58
Wide drill[b,c]	12.00	20	1	0.60
Clinical time*	10.00	-	-	-

*Was calculated individually considering the time to remove each post on each tooth; ([a]) ultrasound tip group; ([b]) diamond bur group; (c) combination group.

About cost comparison between groups, data were statistically significant among some of the cost comparisons. The following comparisons presented statistically significances difference: Glass fiber post removed with ultrasound tip vs combination (P=0.0065); Glass fiber post and diamond bur vs combination (P=0.0210). For the cast metal post removed technique with ultrasound vs cast metal post and diamond bur (P=0.0153); cast metal post and ultrasound vs combination (P=0.002); and cast metal post and diamond bur vs combination (P=0.0002).

Discussion

According to the literature, there is still no consensus on which technique for post removal, whether glass fiber post and/or cast metal post is the most indicated[16]. This study aimed to answer which is the best technique for removing glass fiber posts and cast metal posts considering time, preservation of tooth structure, and costs. This study brings critical clinical data that will consider important factors for choosing the dentist in your office. Endodontically treated teeth may have a small amount of remaining coronary dentin, which directly influences the clinical survival of posts and restorations[17]. It is important that the technique used not only generates the lowest costs and time but also the lowest loss of tooth structure, as it reflects the longevity of the teeth. Thus, the hypothesis tested was accepted in part, since the use of an ultrasound tip in a cast metal post was one of the cheapest techniques and presented the least loss of tooth structure in both groups (glass fiber posts and cast metal posts).

The removal of root canal posts is widely used in the case of root canal retreatment, and several techniques are used, associated or not, aiming at the lowest removal of the inner part of the root canals [18]. Current removal techniques involve the use of burs (diamond, Gates Glidden, Largo, Peeso, and post system removal kit burs), ultrasound, and laser, each varying in procedure time and tooth structure preservation. It is important to note that the post material, shape, length, type of cementation, dental tissue integrity, post retention, and technology used in this procedure are analyzed[18,19]. In this study, the following techniques were applied: Glass fiber with ultrasound tip; Glass fiber with diamond bur; Glass fiber combination; Cast metal with ultrasound tip; Cast metal with diamond bur; Cast metal combination.

In this study, it was observed that there were no differences in the time required to remove the posts among the different techniques tested. Time was similar for all groups and therefore cannot be

a criterion that directs the choice of root canal post-removal technique. Yet, the time to complete fiber post removal was the most evaluated outcome by the studies included in a review comparing techniques for removing fiber endodontic posts. Manufactured removal kits, in general, proved to be faster when compared to ultrasound[18]. This unfavorable data for ultrasound is also shown in a primary study, where laser allowed removal in approximately 1.5 min, while ultrasound took almost 10 minutes[19]. Although the time factor is clinically relevant, variables such as preservation of tooth structure, safety, and efficacy may have more impact on the prognosis and the remaining tooth to be restored[18].

In teeth where the post fracture occurred, for the complete removal of the post from the root canal, there will be greater removal of the tooth structure, since it will be necessary to associate other methods for the complete removal[21], this data was not considered in this study. The removal of sound tooth structure from the middle area of the root canal was not considered, the removal of glass fiber posts with diamond burs was the one that produced the greatest removal of tooth structure. Given the failures that have occurred, it can be mentioned that glass fiber posts are more likely to require complete post-removal using diamond burs rather than removing the post at once. The reason this happened is likely that these posts adhere tightly to the resin cement and root dentin. On the other hand, cast metal posts were less resistant to removal and were removed from the root canal without greater risk. According to the scientific evidence, no significant differences in fracture incidence were found between the two root canal post systems in the meta-analysis of the two remaining studies[4,22]. Some studies indicate that root fractures are generally more unfavorable and catastrophic with metal posts[23].

Regarding the analysis of the loss of tooth structure, this evaluation becomes important during the removal of endodontic posts since the measurement of the remaining tooth directly reflects the possibility of tooth fracture and the success of the treatment. The amount of tooth structure removed may vary depending on the technique and instruments used and further studies may be necessary. Several authors use an ultrasound tip for post-removal, emphasizing greater safety and preservation of the dental structure[1,7,24]. Therefore, this criterion becomes important in the selection of a technique for post-root canal removal. According to the results of this study, the loss of tooth structure occurs independently of the technique, and the difference between the groups is statistically significant. Techniques using diamond burs increase the removal of tooth structure. Therefore, it is more conservative to choose techniques that use the ultrasound tip alone or in combination[7,24].

The analysis of the loss of tooth structure was performed using periapical radiographs. Thus, it is important to emphasize that the measurements were obtained from 2D images, which is a limitation of this study. Cone-beam tomography could have given precise results, but radiographs provide important information about the loss of tooth structure that occurs after the removal of the posts in any post-removal technique and clinicians will most likely use radiographs in those cases[25]. The long-term survival of ETT with extensive coronary tissue loss is highly uncertain and can be quite different from the mid-term outcomes, which can interfere with the evidence generated in the long term[8]. Some

factors such as cement type, other types of posts, and patient-related issues may influence the root canal post-removal and may be tested in future studies.[3,7,22]

Additional laboratory studies are needed to evaluate in vitro the cost, preservation of tooth structure, and clinical time, in addition to a greater number of variables. In addition, further studies are needed to confirm the difference in techniques considering the type of cement and the type of post. There is a cost difference among techniques, which would generate an important discussion for the clinical evidence according to the cost-benefit of each technique, but the main issue should be the minimum loss of tooth structure[3,18]. The decision of removal technique can directly influence the success of the treatment and prognosis of the case, and the literature should point out their risks and benefits to aid the decision-making of dentists.

Conclusion

Removing glass fiber posts offers a higher degree of difficulty compared to cast metal posts, with more tooth structure loss and longer clinical chair time needed. Choosing to remove posts with diamond burs can result in greater tooth structure removal compared to other techniques.

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Abstract

Objective: The aim of this study was to answer which is the best technique to removing glass fiber post and cast metal post considering time, preservation of tooth structure, and costs. Methods: An in vitro, randomized, blinded study was conducted. Sixty endodontically treated teeth were randomized into two groups according to post type. A second randomization was performed for each type of removal technique (ultrasound, drill, or combined; n=10). One-way ANOVA was used to compare the time to post removal, paired t-test compared the amount of tooth structure removed and Kruskal Wallis followed by post hoc Mann-Whitney test were used for cost analysis (P=0.05). Results: There was no difference in post removal time considering post type or technique (P=0.630). The average loss of tooth structure in the cervical region was greater than 30% when only a diamond bur was used to remove fiber glass post (P<0.00001) and cast metal post (P=0.008). Conclusion: According to the results of this study, we can conclude that the selection of the removal technique will depend on the skill of the operator, and some loss of tooth structure will always occur, although greater loss is expected when only diamond burs are used for this purpose.

Key words: Post and Core Technique, Costs and cost Analysis, Post-removal, Fiberglass Cast, In Vitro Techniques.

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