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Evaluation of several protocols for the application of ultrasound during the removal of cast intraradicular posts cemented with zinc phosphate cement

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Abstract

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Aim To evaluate several protocols for the application of ultrasound during removal of cast posts with varying core configurations cemented with zinc phosphate.

Methodology Sixty maxillary canines were distributed into three groups ($n = 20$): group 1 – core with 5 mm diameter/height and post diameter of 1.3 mm; groups 2 and 3 – core with the same diameter as the post (1.3 mm) and heights of 5 mm and 3 mm, respectively. Posts/cores were cemented using a standard technique with zinc phosphate cement. Each group was divided into two subgroups according to the ultrasonic vibration mode: point vibration – ultrasonic vibration applied to the core surface for 5 s, on each face totalling 25 s; alternate vibration – intermittent application of ultrasonic vibration for 10 s to the labial and lingual surfaces, 10 s to the mesial and distal surfaces and 5 s to the incisal surface, totalling 25 s. The specimens were submitted to the tensile test using an Instron machine (1 mm min^{-1}) and results were analysed by ANOVA and *t*-test. The failure type was also analysed.

Results Statistical analysis showed significant differences between groups relating to the core preparations ($P < 0.05$). The lowest mean values of traction force were obtained for group 3 (46.1 ± 7.7 N), followed by group 2 (89.0 ± 2.7 N) and group 1 (160.4 ± 7.5 N). Regarding ultrasonic vibration, the lowest mean was observed with alternate vibration (81.1 ± 10.1 N), which was significantly lower than the point vibration (115.9 ± 9.5 N) ($P < 0.05$). Cohesive failure occurred in all cases.

Conclusion A reduction in core diameter/height and intermittent ultrasonic application improved the removal of cast posts cemented with zinc phosphate.

Keywords: cast post, post removal, ultrasound, zinc phosphate cement.

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Introduction

The removal of an intraradicular post is often difficult, time consuming with a risk of accidents (Bando *et al.* 1985, Yoshida *et al.* 1997). The level of difficulty involved in removing posts is related to several factors including length, form, diameter, type of post and cement used, as well as the professional ability and technical resources available (Lindemann *et al.* 2005, Peciuliene *et al.* 2005).

There are several techniques and instruments recommended for the removal of intraradicular posts. Some techniques have been proposed for the removal of a post by gripping and/or traction, such as: the Saca-Pino post extractor (Shemen & Cardash 1985), the Little Giant post puller (Bando *et al.* 1985), the Gonon extractor (Sakkal *et al.* 1994), the Masseran technique (Williams

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& Bjorndal 1983), the pneumatic extractor (Anon 2001), as well as the use of special forceps and haemostatic tweezers. Other techniques for the removal of intraradicular posts involve rotary instruments and are called 'wearing' techniques (Lindemann *et al.* 2005).

Although adequate, these instruments and techniques can lead to root fracture during gripping and removal of the post, excessive removal of dentine around the post and risk of lateral perforation of the root (Abbott 2002).

In relation to these undesirable occurrences, much focus has been directed toward ultrasound for the removal of intraradicular posts (Smith 2001, Dixon *et al.* 2002, Silva *et al.* 2004, Peciuliene *et al.* 2005, Garrido *et al.* 2007). The use of ultrasound appears to be a safe and simple technique, which can reduce the operating time and the physical demands on the operators (Castrisos & Abbott 2002, Plotino *et al.* 2007).

Ultrasonic vibration alone does not allow a safe, efficient and rapid removal of posts. Therefore, several clinical protocols for intraradicular post removal with ultrasound have been recommended with the aim of facilitating the procedure, reducing the operating time and minimizing the risks to the root (Yoshida *et al.* 1997, Alfredo *et al.* 2004, Garrido *et al.* 2004, Braga *et al.* 2005).

Ruddle (2004) reported that the ultrasonic tip should be applied at the metal/canal wall interface, encircling the post in order to expose the cement line. Alfredo *et al.* (2004) observed that a reduction in the core diameter led to an increase in ultrasonic efficiency, reducing the traction force required to remove posts by 24%. Garrido *et al.* (2004) verified that cooling can influence the efficacy of the ultrasonic vibration depending on the type of cement used for fixing the posts. Likewise, Braga *et al.* (2005) reported a greater efficacy in the removal of posts when two ultrasonic tips were used simultaneously on opposite faces of the core.

The present study evaluated how variations in the diameter and height of the core (extraradicular portion), as well as the movement applied to the ultrasonic tip, influenced the removal efficacy of cast posts cemented with zinc phosphate cement.

Materials and methods

Sixty human mandibular canines were selected according to the form and length of the root (straight with single canal roots and approximately 15 mm in length). These teeth were sectioned transversally close to the cementoenamel junction with carborundum discs under water spray cooling. After sectioning, the roots were standardized to 13 mm lengths. Samples were then embedded in acrylic resin using a rectangular aluminum matrix and stored at 37 °C (±2 °C) with 100% relative humidity, in hermetically sealed containers, until the following stage.

The root canals were prepared to a working length of 12 mm (1 mm before the apical foramen) with K-type files up to size 50 diameter. Irrigation was carried out with 1% sodium hypochlorite between each file. The root canals were filled with gutta-percha points and Sealer 26 cement (Dentsply-Brazil, Rio de Janeiro, RJ, Brazil) using the lateral compaction technique. After filling, the root canals were sealed coronally with Coltosol (Vigodent, Rio de Janeiro, RJ, Brazil) and stored in distilled water at 37 °C for 7 days. The filled canals were then prepared with size 6 Largo burs (9-mm length and 1.3-mm diameter) with a handpiece at low speed coupled to a parallelometer, in order to assure that the preparations remained parallel to the long axis of the roots.

The preparation of the intraradicular post was carried out in two stages: post production and core carving. Posts were prepared using a direct technique with chemically activated acrylic resin (Duralay, Reliance, Dental Mfg. Co., Worth, IL, USA) and Pin-Jet prefabricated posts (Angelus, Londrina, PR, Brazil), to create posts with a diameter compatible with the size 6 Largo bur and equivalent to a 1.3-mm diameter.

Before carving the core, the specimens were randomly distributed into three groups (n = 20) according to the diameter and height of the core:

- Group 1 – core with 5 mm diameter and 5 mm height and post with 1.3 mm diameter;
- Group 2 – core with the same diameter of the post (1.3 mm) and 5 mm height;
- Group 3 – core with the same diameter of the post (1.3 mm) and 3 mm height.

The core was carved in wax for casting, to reproduce the core according to the dimensions established for each group. The measurements of the core of each specimen were validated with a digital paquimeter in the mesio-distal, labial-lingual and cervical-incisal directions in order to maintain standardization. On the proximal faces of the core, a yellow wax cylinder 8 mm diameter was placed (Polidental, São Paulo, SP, Brazil), to enable the specimens to be gripped in the Universal testing machine (Instron Corporation, Canton, MA, USA) during the traction test (Fig. 1).

The resin patterns were cast in nickel–chromium alloy (Goldent L.A., São Paulo, SP, Brazil). The posts

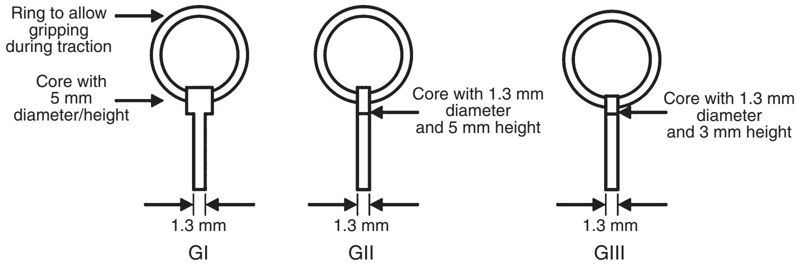

Figure 1 Schematic drawing of the dimensions of the coronary portion and apparatus in traction test on the Universal testing machine.

were then sprayed with aluminium oxide. After casting and spraying, the posts were tried-in to the root canals (8-mm length) and were then cemented using zinc phosphate cement (LS; Vivadent, Rio de Janeiro, RJ, Brazil). The cement was introduced in the canals using lentulo fillers (Dentsply Maillefer, Ballaigues, Switzerland). Posts were covered with cement and inserted into the root space and specimens were stored at 100% relative humidity at 37 °C for 3 weeks.

Each group was divided into two subgroups according to the application of the ultrasonic vibration: subgroup A – (point vibration) – application of ultrasonic vibration at the centre of each face of the post, using point vibration, for 5 s on each face (B, L, M, D and I), totalling 25 s; subgroup B – (alternate vibration) – 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, totalling 25 s.

The ultrasonic vibration was carried out with an ENAC ultrasound device, model OE-5 (Osada Electric Co., Ltd, Tokyo, Japan), with cooling, using a ST-09 tip. The ultrasonic device was activated at maximum vibration (30 kHz) applying the movements predefined for each subgroup.

Immediately after the ultrasonic vibration, the specimens were submitted to a traction test on a Universal testing machine (Instron 4444; Instron Corporation). The specimens were positioned individually in the fixing device on the base of the Universal testing machine, with the aim of minimizing the lateral forces and maintaining the traction on the long axis of the root. An increasing traction force was applied to the core, with a crosshead speed of 1 mm min^{-1}, until the post was completely detached from the root. The results for the maximum traction forces, obtained in Newtons, were noted and submitted to statistical tests through analysis of variance and *t*-test.

With the aid of a stereoscopic magnifying glass (Stemi 2000-C; Zeiss, Jena, Germany), under 25× magnification, the type of failure occurred in the specimens after the traction test was analysed, an adhesive failure being recorded when it occurred between the surfaces of different elements (cement/tooth or cement/post interface), cohesive failure when it occurred between surfaces of the same substance (cement) and mixed when it occurred through a combination of these ruptures.

Results

Table 1 shows the traction force (Newtons) required for the removal of intraradicular posts in each experimental group.

The analysis of variance demonstrated significant statistical difference ($P < 0.05$) for both factors: core configuration and form of application of the ultrasonic vibration.

Table 1 Values in Newtons of the traction force required for the removal of intraradicular posts

Application of vibration	Core preparation		
	Group 1	Group 2	Group 3
A	152.1	089.4	055.0
	165.0	099.4	049.2
	190.9	091.9	030.4
	249.7	090.5	046.3
	219.8	115.6	030.9
	1951.0	108.9	061.0
	170.6	089.8	117.6
	167.4	081.4	100.9
	154.7	091.0	108.5
	152.6	110.7	090.0
	$\overline{X}$ = 181.8 ± 10.2	$\overline{X}$ = 96.9 ± 3.5	$\overline{X}$ = 69.0 ± 10.3
B	148.7	079.6	003.1
	115.9	074.1	014.1
	116.5	073.2	002.6
	124.8	079.5	002.5
	124.6	087.8	038.0
	169.8	085.2	014.2
	146.7	082.8	042.5
	152.4	081.0	037.7
	142.0	087.0	0039.1
	149.3	080.9	0038.6
	$\overline{X}$ = 139.1 ± 5.6	$\overline{X}$ = 81.1 ± 1.7	$\overline{X}$ = 23.2 ± 5.5

The *t*-test showed significant statistical difference among all groups relating to the core preparations ($P < 0.05$). The lowest average for the traction force were obtained for group 3 (46.1 ± 7.7 N), followed by group 2 (89.0 ± 2.7 N) and group 1 (160.4 ± 7.5 N). The smallest mean values were observed in the group with the small diameter and height of core.

In relation to the vibration methods, lower mean values were achieved with alternate vibration, that is, subgroup B (81.1 ± 10.1 N), which differed significantly ($P < 0.05$) from point vibration, that is, subgroup A (115.9 ± 9.5 N).

Regarding the outcomes obtained for the failure types after the traction tests, the presence of cement adhered to the post and canal walls was observed for all specimens, verifying that cohesive failure occurred in all cases.

Discussion

The results obtained in this study showed that in the groups where the cores had the same diameter as the posts, the force required for the dislodgement of posts, after the ultrasonic vibration regardless of the form of its application, was lower and statistically different to those specimens which had a core with a diameter greater than that of the post. In this situation the force reduced by 47% when the diameter decreased and by 71% when the diameter and height of the core was reduced. These results are in agreement with those obtained by Alfredo *et al.* (2004), who observed that the procedure of decreasing the core diameter reduced the traction force required by 24%.

The decrease in the core diameter leads to the exposure of the cementation line, enabling the direct action of ultrasonic vibration on this interface. Thus, it can be assumed that the reduction of the traction force required for the removal of the posts is related, at least in part, to the fragmentation of the zinc phosphate cement by the ultrasonic vibration. According to Garrido *et al.* (2004), the low resistance to traction of zinc phosphate cement, compared with its high resistance to compression, places zinc phosphate cement in the friable materials category.

Based on this premise, Ruddle (1997) recommended that, before the application of the ultrasound, the cement line should be exposed by means of a gap between the core and the canal wall in order to increase the efficacy of ultrasound. The reduction of the core diameter enabled a smaller area of contact between the core and the root face, a factor favouring the concentration of ultrasonic vibration on the post/cement/root interface and, thus contributing to increase the ultrasound efficacy in the post dislodgement, which is in agreement with Alfredo *et al.* (2004).

In relation to the height of the core, the results obtained in this study revealed that ultrasonic vibration on shorter cores (3-mm height) reduced the traction force required when compared with cores with 5-mm height. It can be assumed that the reduced mass of the core dissipated the ultrasonic waves more effectively, allowing them to reach more easily the zinc phosphate cement used to fix the post to the canal wall.

The ultrasonic tip was applied in two distinct ways: point vibration in all faces of the core (including the incisal face) and alternate vibration in labial-lingual, mesio-distal and incisal faces. The time of application on each face was 5 s. The results revealed that when cores were submitted to alternate vibration, the traction force required to dislodge them was lower than that required for those submitted to point vibration. The greater efficacy of alternate vibration in relation to point vibration may be related to the greater fragmentation of the cement which occurred in a dynamic way on both faces of the post (mesio-distal and labial-lingual).

The alternating type of ultrasonic application may have a further advantage over point vibration since it reduces the excessive frictions between the ultrasonic tip and metal, hence minimizing the release of heat. The application of point vibration to the metal post, without intermittence, may generate excessive heat (Dominici *et al.* 2005, Ettrich *et al.* 2007) without increasing its efficacy, as observed in this study. This may expose the periodontal ligament and dental tissues to damage, besides jeopardizing the performance of the ultrasonic device.

The analysis of the failure type that occurred after the removal of posts by traction revealed cohesive failure in all specimens, since the cement itself ruptured. These results are in agreement with El-Mowafy & Milenkovic (1994) who showed that adhesive failure occurs in posts cemented with resinous cement and cohesive failure is common with posts cemented with zinc phosphate.

According to Buoncristiani *et al.* (1994), the module of elasticity of metallic posts interferes with the efficiency of ultrasonics. Rigid materials, with a high module of elasticity, tend to perform better with ultrasonic vibration, and hence, increase its efficiency; while materials with a low modulus of elasticity reduce the efficiency of ultrasonics. Titanium has a module of elasticity smaller than stainless steel, which reduces the efficiency of ultrasonics. In this study, the cast post were made of nickel–chrome, a hard and inflexible material, however, it is not possible to guarantee the efficiency of such protocol for posts made with other metallic materials such as gold and titanium.

Overall, the results of this study verify that the reduction of the core diameter and height, as well as the application of alternating movements of the ultrasonic tip are important technical issues that enhance the efficacy of ultrasonics during the removal of cast posts cemented with zinc phosphate cement. However, these results cannot be directly extrapolated to a clinical situation.

Conclusion

The use of procedures prior to ultrasound, such as the reduction in diameter/height of the core, as well as the ultrasonic application mode, improved the removal efficacy of cast posts cemented with zinc phosphate cement.

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