JOURNAL OF ENDODONTICS
Copyright © 2004 by The American Association of Endodontists

Printed in U.S.A.
VOL. 30, NO. 3, MARCH 2004

Influence of Ultrasound, With and Without Water Spray Cooling, on Removal of Posts Cemented With Resin or Zinc Phosphate Cements

Ângela Delfina Bittencourt Garrido, DDS, MSc, Tabajara Sabbag Fonseca, DDS, Edson Alfredo, DDS, MSc, Yara Teresinha Corrêa Silva-Sousa, DDS, MSc, PhD, and Manoel D. Sousa-Neto, DDS, MSc, PhD

The efficacy of ultrasound, with and without water spray, was evaluated in vitro on the amount of force necessary to dislodge posts cemented with resin or zinc phosphate. Forty-two samples were divided into six groups: groups 1, 2, and 3, posts cemented with zinc phosphate; groups 4, 5, and 6, posts cemented with resin (Panavia F); groups 1 and 4 (controls), no ultrasound; groups 2 and 5, ultrasound without water spray; and groups 3 and 6, ultrasound with water spray. The Instron testing machine was used. Ultrasound without water spray significantly reduced (71%) the force necessary to displace posts cemented with Panavia F ($p < 0.01$); however, this value was similar to the efficacy of ultrasound with water spray for posts cemented with zinc phosphate (reduction of 75%). We conclude that cooling with ultrasound interferes with the force necessary for post removal, depending on the type of cement used.

Endodontic retreatment of teeth with posts presents a great challenge to the clinician; post removal is necessary and there must be no excessive wearing of the surrounding dentin because of the risk of root perforation. Many techniques and instruments are advocated for post removal. Some authors remove the post by gripping and pulling with such instruments as the pivots-extracting forceps post extractor (1, 2), the post puller (3), the Gonon extractor (4), the Masserann technique (5), and special forceps and hemostats. Other techniques use rotary instruments (wearing technique) and ultrasound alone or in combination with other techniques (6, 7).

The efficacy of ultrasonic vibration in removing posts cemented with zinc phosphate is already known. However, there is little research regarding the efficacy of ultrasound in removing posts fixed with resin cements. According to Nahmias (8) and Gomes et al. (9), posts fixed with resin cements are resistant to ultrasonic vibration.

Resin cements have been indicated for fixing metallic elements because of their superior performance in adhesion tests and reduction of coronal microleakage (10). Despite these desirable characteristics, clinicians who use resin cements must be aware of the difficulty in their removal from the root canal if necessary (11). The use of heat as an auxiliary aid to remove posts fixed with resin cements has been suggested (9). Water spray is a common technique to minimize heat generation during application of ultrasonic forces. However, there is a gap in knowledge about whether water spray and ultrasonic forces interact to alter the force required for removal of resin-cemented posts.

Thus, the objective of the present research was to evaluate in vitro the ultrasonic vibration efficacy, with and without water spray cooling, on the reduction of force necessary to dislodge die cast posts cemented with resin cement versus those cemented with a zinc phosphate cement.

MATERIAL AND METHODS

A total of 42 maxillary human canines were selected according to the shape and length of the roots (single canal and straight root, approximately 15 mm in length). These teeth were sectioned transversally near the cementoenamel junction with carborundum discs with water spray cooling. After sectioning, all roots were 13 mm long. Samples were embedded in acrylic resin using a rectangular aluminum mold and kept in a hermetically sealed container with distilled water throughout the experiment.

The root canals were instrumented to a working length of 12 mm (1 mm from the anatomical apex) with K-files to a #50 (master apical file). Irrigation was performed with 1% sodium hypochlorite between files. Root canals were obturated with gutta-percha points and Sealer AH26 (Dentsply-Brazil, Rio de Janeiro, RJ, Brazil) using the lateral condensation technique. After obturation, the canals were sealed with Coltosol (Vigodent, Rio de Janeiro, RJ, Brazil), and samples were kept in distilled water at 37°C for 7 days. Root canals were subsequently prepared for dowel impression with a number 6 Largo bur (9 mm length, 1.3 mm diameter) to standardize the length and diameter of post preparation. This step was performed with a low-speed handpiece attached to a parallelometer to standardize vertical preparations. Root canal impressions were

TABLE 1. Values, in kilonewtons, of forces necessary to displace posts

Cements	Post extraction techniques		
	Without ultrasound	Ultrasound without water spray	Ultrasound with water spray
Zinc phosphate	0.37	0.31	0.09
	0.40	0.16	0.17
	0.27	0.11	0.04
	0.35	0.19	0.24
	0.55	0.35	0.01
	0.30	0.37	0.01
	0.54	0.36	0.13
Mean ± SD	0.40 ± 0.11[a]	0.26 ± 0.10[a]	0.10 ± 0.09[b]
Panavia F	0.38	0.10	0.28
	0.28	0.10	0.26
	0.32	0.08	0.20
	0.34	0.11	0.29
	0.26	0.10	0.20
	0.37	0.10	0.32
	0.45	0.10	0.23
Mean ± SD	0.34 ± 0.07[a]	0.10 ± 0.01[b]	0.25 ± 0.05[a]

[a,b] Means with different superscript letters were significantly different ($p < 0.01$).

then taken using chemically activated acrylic resin (Duralay; Reliance Dental, Worth, IL).

Impressions were cast in copper-aluminum alloy (Duracast), and posts received an aluminum oxide blast and were adjusted to the root canals. The post was 8 mm long, and the core was 5 mm. To adapt to the Instron testing machine, an 8-mm ring was attached.

Samples were divided randomly into six groups of seven teeth each. Posts from groups 1, 2, and 3 were fixed with zinc phosphate cement (LS, Vivadent, Rio de Janeiro, RJ, Brazil), and posts from groups 4, 5, and 6 were fixed with resin cement (Panavia F, Kuraray Co. Ltd., Japan). All samples were kept in distilled water at 37°C for 3 weeks before receiving the following treatments:

Group 1: posts fixed with zinc phosphate cement, no ultrasound (control group)
Group 2: posts fixed with zinc phosphate cement, ultrasound without water spray
Group 3: posts fixed with zinc phosphate cement, ultrasound with water spray
Group 4: posts fixed with Panavia F, no ultrasound (control group)
Group 5: posts fixed with Panavia F, ultrasound without water spray
Group 6: posts fixed with Panavia F, ultrasound with water spray

Ultrasound was applied using an ENAC unit (model OE-5, Osada Electric Co. Ltd., Tokyo, Japan) with an ST-09 tip (Osada Electric Co. Ltd.). Samples were stabilized in a bench vise, and the ultrasound unit was set to maximum power and applied for 1 min at buccal, lingual, and proximal surfaces of the post, for a total of 4 min for each sample, controlled with a timer.

The resin blocks were placed in a fixed rectangular base in an Instron testing machine in order to be held secure and minimize lateral forces, maintaining the sample in a vertical position to apply forces parallel to the root axis. The posts were submitted to increasing traction forces (0.5 mm/min) until their displacement from the root. The maximum force in kilonewtons (kN) was recorded and submitted to statistical analysis with analysis of variance and the Tukey test.

RESULTS

The data consisted of 42 numeric values of force (kN) necessary to displace the posts and are shown in Table 1.

Statistical analysis with analysis of variance showed differences ($p < 0.01$) between post extraction techniques and interactions between techniques versus cements. The Tukey test indicated that groups $1=2=4=6 \neq$ groups $3=5$.

In groups in which posts were cemented with Panavia F, ultrasonic vibration without water spray reduced the traction force necessary to remove the post by 71%. This value was statistically different ($p < 0.01$) from values obtained in the control group and in groups in which water spray cooling was used. These last two groups were statistically similar.

On the other hand, among the groups cemented with zinc phosphate cement, ultrasonic vibration with water spray reduced the traction force necessary to dislodge the post by 75%. This value was statistically different ($p < 0.01$) from values obtained in the control group and in groups in which water spray cooling was not used. These last two groups were statistically similar. Fig. 1 shows the force necessary to extract the posts.

DISCUSSION

The oscillatory movements of ultrasound propagate along the tips used and are transferred to the post to break the interface between the post and the canal walls, dislodging the post or minimizing the forces necessary to achieve this goal. Ultrasound is considered the safest and most efficient technique because it saves time, there is minimal wearing of tooth structure, there is a low risk of fracture or perforation, and the technique is applicable to all teeth (12).

The results obtained in this study demonstrated that in groups in which the posts were fixed with zinc phosphate, ultrasound applied with water spray cooling (group 3) reduced the traction force necessary to extract posts by 75% when compared with the control group (group 1). However, ultrasonic vibration without water spray

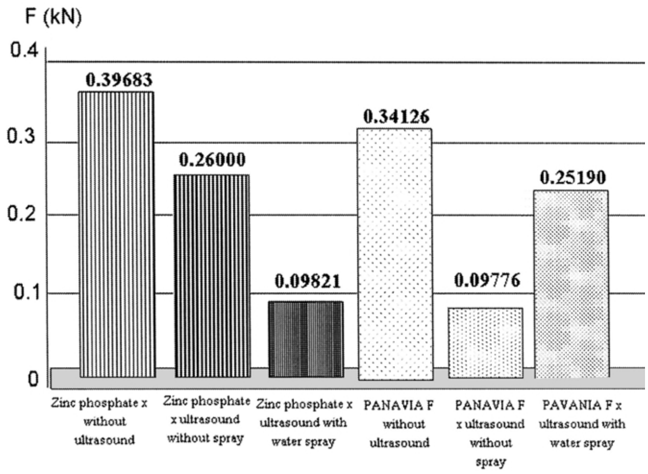

FIG. 1. Graphic representation of the traction forces (kN) necessary to extract the posts and the interaction between techniques and cements.

(group 2) did not produce the same results, with no statistical differences between this group and the control group.

Berbert et al. (13) observed that the forces necessary to remove posts that received ultrasonic vibrations were, on average, 30% to 35% lower than those of the control group, which did not receive ultrasonic vibrations. In the present study, the ultrasound reduced the force necessary to extract the posts by as much as 75%. However, the ultrasound device used by Berbert et al. (13) was the magnetostrictive kind, which converts magnetic energy into mechanical. This is not an efficient transformation, leading to reduced ultrasonic energy. The device used in the present experiment was piezoelectric, which converts electric energy into mechanical without the loss of energy, and consequently, with constant ultrasound frequency.

Gomes et al. (9), using a piezoelectric ultrasound device for 10 min, were able to reduce the force necessary to extract the posts by 39% when compared with the control group, a value less than that of the present study (75%). It is worthwhile to note that the maximum frequency of the device used by Gomes et al. (9) was 29 kHz, which is less than the ENAC ultrasound used in the present research (more than 30 kHz). It is also important that Gomes et al. (9) used the ultrasonic tip at the incisal edge and the tooth-core interface, whereas the present study used the tip on the buccal, lingual, and proximal surfaces. It is possible that either factor contributed to the differences between these studies.

The low resistance to traction, compared with its high resistance to compression forces, places the zinc phosphate cement in the friable materials category (14). The ultrasonic vibration was efficient in posts fixed with zinc phosphate cement because the mechanical impact of the ultrasound was transferred to the post, probably breaking the luting layer between the post and the canal walls, minimizing the force necessary to dislodge the post. Water spray must also be considered because it affects the solubility of zinc phosphate cement (14), particularly with continuous application of the water stream, thus promoting the solubility of the cement. The inefficacy of ultrasound without water spray on posts cemented with zinc phosphate is probably related to the low thermal expansion values for this luting agent, which does not compromise its physicochemical properties by increasing temperature (14, 15). The absence of cooling allows the ultrasound to generate mainly thermal energy instead of mechanical energy, which is responsible for its efficiency. The results of the present study are in agreement with those of Bergeron et al. (16), who used an ultrasound device without water spray, failing to achieve success in removing posts fixed with zinc phosphate.

The fact that ultrasonic vibration with water spray did not present statistically significant differences ($p > 0.01$) in posts fixed with resin cement (group 6) when compared with the control group (group 4) is in agreement with the findings of Gomes et al. (9), who demonstrated that ultrasonic vibration is not efficient with resin luting agents. According to Phillips (14), resin cements are not friable and do not tend to produce microfractures, as is seen with zinc phosphate cements. According to Buoncristiani et al. (17), resin cements present elasticity values similar to those of plastic materials and tend to absorb the energy transmitted to the post. Among the groups in which posts were fixed using resin cements, ultrasound without water spray (group 5) produced lower traction force values that were statistically different ($p < 0.01$) from those of the control group (group 4) (reduction of 71.2%).

The absence of water spray seems to increase the action of ultrasound when applied to posts cemented with resin cements. However, it cannot be stated that ultrasound is efficient on resin cements, because it probably acts indirectly by means of heat production, and not by its movement. Considering the high thermal conductance of metals, the heat generated by the ultrasonic tip and post metallic alloy is easily transmitted to the luting agents. Resins show a high thermal expansion value and thus are susceptible to temperature changes (14, 15).

Watanable et al. (18) observed that the adhesion capacity of a resin cement reduces gradually with the number of thermal cycles. Thus, with heat, resins expand and compromise their chemical properties of adhesion and, consequently, mechanical retention. This change favors the dislodgment of posts fixed with resin cements, particularly when ultrasonic forces are applied over time (4 min in the present study).

The presence or absence of water spray interferes in the efficacy of ultrasound, depending on the cement, and can reduce the force necessary to extract posts by approximately 73%, increasing the predictability of success. The present research showed that the use of ultrasound without water spray cooling is an efficient technique for removing die cast posts fixed with resin cements, possibly because of the increase in heat. However, the absence of water spray cannot be used clinically, because it is not known whether a 4-min application will produce periodontal injury because of heat. Thus, further research is necessary to confirm alternatives scientifically for the removal of die cast posts fixed with resin cements in a safe and effective manner.

Dr. Garrido and Dr. Fonseca are graduate students and Dr. Alfredo, Dr. Silva-Sousa, and Dr. Sousa-Neto are professors of the Faculty of Dentistry, University of Ribeirão Preto, Ribeirão Preto, SP, Brazil.

Address requests for reprints to Dr. Sousa-Neto, R. Célia de Oliveira Meirelis, 350, Jd. Canadá/Ribeirão Preto/SP/Brazil, 14024-070.

References

1. Neaverth JREJ, Kahn H. Retreatment of dowel-obturated root canals. J Am Dent Assoc 1968;76:325–8.
2. Shemen BB, Cardash HS. A technique for removing cemented posts. J Prosthet Dent 1985;54:200–1.
3. Bando E, Kawashima T, Tiu IT, Kubo Y, Nakano M. Removing dowels in difficult teeth. J Prosthet Dent 1985;54:34–6.
4. Sakal S, Gauthier G, Milot P, Lemian L. A clinical appraisal of the Gonon post-pulling system. J Can Dent Assoc 1994;60:537–9.
5. Williams VD, Bjorndal AM. The Masserann technique for the removal of

fractured posts in endodontically treated teeth. J Prosthet Dent 1983;49: 46–8.

6. Castrisos T, Abbott PV. A survey of methods used for post removal in specialist endodontic practice. Int Endod 2002;35:172–80.

7. Dixon EB, Kackowski PJ, Nicholls JI, Harrington GW. Comparison of two ultrasonic instruments for post removal. J Endodon 2002;28:111–5.

8. Nahmias Y. A new post removal system. Oral Health 1999;89:47–8.

9. Gomes AP, Kubo CH, Santos RA, Santos DR, Padilha RQ. The influence of ultrasound on the retention of cast posts cemented with different agents. Int Endod J 2001;34:93–9.

10. Bachicha WS, Difiore PM, Miller DA, Lautenschlager EP, Pashley DH. Microleakage of endodontically treated teeth restored with posts. J Endodon 1998;24:703–8.

11. Mitchell CA. Selection of materials for post cementation. Dent Update 2000;27:350–4.

12. Wang XY, Wang ZM, Hong J. Removal of intracanal obstructions with ultrasound: analysis of 206 cases. Chin Med J 1994;107:474–7.

13. Berbert A, Filho MT, Ueno AH, Bramante CM, Ishikiriama A. The influence of ultrasound in removing intraradicular posts. Int Endod 1995;28: 100–2.

14. Phillips RW. Skinner's science of dental materials. 10th ed. Philadelphia, PA: WB Saunders Co, 1996.

15. Craig RG. Cements. In: Craig RG. ed. Restorative dental materials: 9th ed. St. Louis: C.V. Mosby, 1993: p. 179–89.

16. Bergeron BE, Murchison DF, Schindler WG, Walker WA. Effect of ultrasonic vibration and various sealer and cement combinations on titanium post removal. J Endodon 2001;27:13–7.

17. Buoncristiani J, Seto BG, Caputo AA. Evaluation of ultrasonic and sonic instruments for intraradicular post removal. J Endodon 1994;20:486–9.

18. Watanable EK, Yatani H, Yamashita A, Ishikawa K, Suzuki K. Effects of thermocycling on the tensile bond strength between resin cement and dentin surfaces after temporary cement application. Int J Prosthet 1999;12:230–5.