www.scielo.br/jaos

Effect of the simulated periodontal ligament on cast post-and-core removal using an ultrasonic device

Manoel BRITO-JUNIOR[1], Neilor Mateus Antunes BRAGA[2], Danilo Costa RODRIGUES[3], Carla Cristina CAMILO[1], André Luis FARIA-E-SILVA[4]

1- DDS, MSc, Professor of Endodontics, Department of Dentistry, Dental School, State University of Montes Claros, Montes Claros, MG, Brazil.
2- DDS, MSc, Professor of Endodontics, Department of Dentistry, Dental School, FUNORTE, Montes Claros, MG, Brazil.
3- Undergraduate student, Dental School, State University of Montes Claros, Montes Claros, MG, Brazil.
4- DDS, MSc, PhD, Professor of Restorative Clinic, Department of Dentistry, Dental School, State University of Montes Claros, Montes Claros, MG, Brazil.

Corresponding address: André Luis Faria-e-Silva - Campus Universitário Professor Darcy Ribeiro - Vila Mauricéia - 39401-089 - Montes Claros, MG - Brasil
Phone: +55 38 2101.9290 - e-mail: andrelfsilva@hotmail.com

Received: February 25, 2009 - Modification: March 17, 2010 - Accepted: March 26, 2010

ABSTRACT

Objective: The aim of this study was to evaluate the effect of simulated periodontal ligament (SPDL) on custom cast dowel and core removal by ultrasonic vibration. Material and Methods: Thirty-two human maxillary canines were included in resin cylinders with or without SPDL made from polyether impression material. In order to allow tensile testing, the roots included in resin cylinders with SPDL were fixed to cylinders with two stainless steel wires. Post-holes were prepared by standardizing the length at 8 mm and root canal impressions were made with self-cured resin acrylic. Cast dowel and core sets were fabricated and luted with Panavia F resin cement. Half of the samples were submitted to ultrasonic vibration before the tensile test. Data were analyzed statistically by two-way ANOVA and Tukey's post-hoc tests ($p<0.05$). Results: The ultrasonic vibration reduced the tensile strength of the samples directly included in resin cylinders. There was no difference between the values, whether or not ultrasonic vibration was used, when the PDL was simulated. However, the presence of SPDL affected the tensile strength values even when no ultrasonic vibration was applied. Conclusion: Simulation of PDL has an effect on both ultrasonic vibration and tensile testing.

Key words: Post and core technique. Ultrasound. Periodontal ligament.

INTRODUCTION

Intra-radicular posts are commonly used to restore endodontically treated teeth if their remaining coronal tissue could no longer provide adequate support and retention for the restoration[16]. Although the use of prefabricated posts has gained popularity[12,15], for several years custom cast dowel and core has been used to retain restorations with clinical evidence of success[19]. One important advantage of this post system is that the dowel will fit a flared or irregularly shaped canal more closely than prefabricated post systems do[11].

However, although endodontic therapy has shown a high success rate, adverse situations that require endodontic retreatment are not rare[13]. When signs, symptoms and radiographic images suggest the failure of endodontic treatment, an atraumatic and efficient post removal is essential for optimal non-surgical endodontic management. Many techniques were developed to facilitate post removal. Drills and extractors exert high force on the root and may result in root fractures[6]. Another commonly recommended technique is the use of an ultrasonic device[5,7,9]. Ultrasonic energy is transmitted to the post, causing cracks in the cement thus facilitating its removal.

Recent evidence suggests that ultrasonic vibration is a safe and fast method for post removal. However, several *in vitro* studies have evaluated post removal with ultrasonic devices by using roots of extract teeth included in resin cylinders[1-3,14,20]. This procedure is used in order to facilitate handling and test application. However, this does not represent the clinical reality. Clinically, the root is enveloped by periodontal ligament (PDL), which presents higher resiliency than resins used for root inclusion. This difference in resiliencies enables

PDL to dissipate the ultrasonic energy more easily than when the root is included in a resin cylinder[18]. Thus, the facility found in some *in vitro* studies for post removal with ultrasound activation may not be consistent with the clinical reality. The simulation of the PDL in these tests would be important to bring the laboratory findings to clinical application.

The aim of this *in vitro* study was to evaluate the effect of simulated periodontal ligament (SPDL) on custom cast dowel and core removal using an ultrasonic device. The null hypothesis was that the SPDL does not influence the action of the ultrasonic device used to remove the cast dowel and core from the root canal.

MATERIAL AND METHODS

Thirty-two human maxillary canines with mature apices, un-pronounced flattening, roots with no curves and single canal were selected for this study. Crowns were removed in order to obtain a 15-mm-long root remainder. For the endodontic treatment, the root canals were prepared according to a crown-down technique, using stainless-steel K-files and #2 to #4 Gates-Glidden drills (Dentsply Maillefer; Ballaigues, Switzerland). All enlargement procedures were followed by irrigation with a 2.5% sodium hypochlorite solution. Instrumented root canals were obturated with gutta-percha cones and Sealer-26 resin sealer (Dentsply, Petrópolis, RJ, Brazil) using the lateral condensation technique. The filled roots were stored in relative humidity for at least 72 h to allow the resin sealer to set. The specimens were randomly allocated according to presence of SPDL and application of ultrasonic vibration. The experimental design is described at Figure 1.

Half of the roots were included directly in self-cured acrylic resin cylinders (Jet Clássico, São Paulo, SP, Brazil) without SPDL. The external surfaces of the root remainders were dipped into melted wax (Epoxiglass, Diadema, SP, Brazil), resulting in a 0.2 to 0.3-mm-thick wax layer[21]. Afterwards, the wax-covered roots were included in acrylic resin cylinders. After resin polymerization, the roots were removed from the cylinder, the wax removed from the root surface creating a space in the resin cylinder. The polyether impression material (Impregum F, 3M/ESPE, Seefeld, Germany) was mixed and placed in the space created in the resin cylinder. The tooth was re-inserted into the cylinder and the excess material removed with a scalpel blade. In order to allow tensile testing without the root becoming dislodged, the roots included in resin cylinder with SPDL were fixed to cylinders with two stainless steel wires about 1 mm in diameter (Figure 2).

Post-holes were prepared by standardizing the length at 8 mm and preparation was performed with a size 6 largo drill (Dentsply Maillefer). This drill was used with a low-speed handpiece attached to a parallelometer. The root canal impressions were made with self-cured resin acrylic (Duralay, Reliance Dental, Worth, IL, USA). A ring was attached to the core to facilitate the tensile testing. The dowel and cores were cast in a nickel-chromium alloy (Wironia, Bego, Bremen, Germany). All custom cast dowel and cores were luted with dual-cured resin cement (Panavia F; Kuraray, Osaka, Japan), in accordance with the manufacturer's instructions. The specimens were stored in distilled water for 1 week at 37°C.

After the storage period, half of specimens of each inclusion type (with or without SPDL) were submitted to ultrasonic vibration. This was applied by the same calibrated operator, using a piezoelectric ultrasonic device (Enac, Osada Electric Co Ltd., Tokyo, Japan), and an ST 09 tip (Osada Electric Co. Ltd.), at maximum power under water cooling. The vibration was applied for 1 min to the buccal, mesial, lingual, distal, and incisal surfaces, successively, with total application time of 4 min for each sample (Figure 3). Samples were positioned in a universal testing machine (Model 4411, Instron Corp., Canton, MA, USA) and the ring of the core was attached to the load cell (500 N). Tensile load was applied at a crosshead speed of 0.5 mm/min until the cast dowel and core was dislodged (Figure 4). The ultimate tensile strength of each sample was recorded (kgf). Data were analyzed

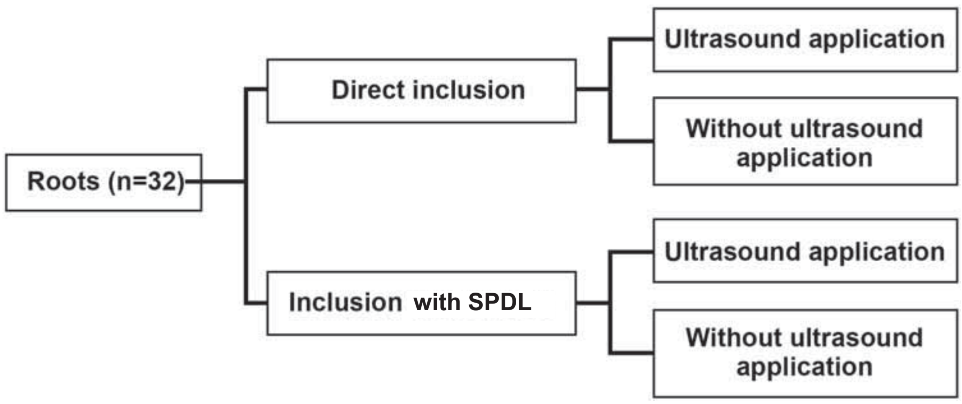

Figure 1- Experimental design

by two-way ANOVA using Assistat 7.5 statistical software. The factors evaluated were "presence of SPDL" and "ultrasonic vibration application". Post-hoc tests were calculated using Tukey`s multiple-comparison test (α=0.05).

Figure 2- Custom cast dowel and core luted in a sample with simulated periodontal ligament. Note the presence of two wires in order to prevent the root dislodgement during testing

RESULTS

There was a statistically significant effect for the factors "presence of SPDL" ($p<0.01$), "ultrasonic vibration application" ($p<0.01$) and for interaction between factors ($p<0.05$). The means tensile strength values in KgF (SD) necessary to dislodge the cast post-and-cores and the results of the Tukey's test are shown in Table 1. When

Figure 3- Application of ultrasonic vibration

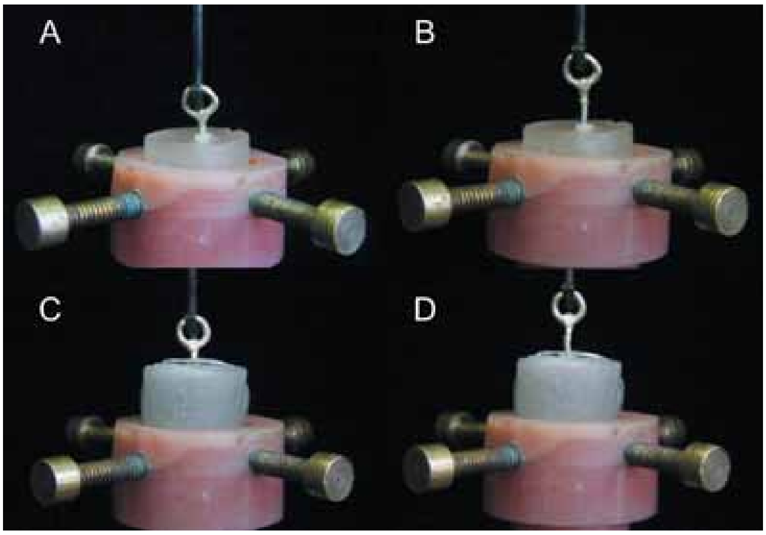

Figure 4- Application of tensile load at samples until dislodgment of the custom cast dowel and core. A and B - without simulated periodontal ligament; C and D - with simulated periodontal ligament

Table 1- Tensile strength means values in KgF (SD) necessary to dislodge the cast post-and-cores

Simulated periodontal ligament	Ultrasonic application	
	No	Yes
Present	11.52 (3.38) Ba	10.83 (2.82) Aa
Absent	22.12 (5.91) Aa	13.02 (8.33) Ab

Means followed by different upper case letters in columns and lowercase letters in rows differ from each other (Tukey's test; 95% confidence level).

ultrasonic vibration was not applied, samples with SPDL presented the lowest tensile bond strength values. No significant differences were observed in the presence or absence of SPDL in samples submitted to ultrasonic vibration. Ultrasonic vibration application led to the lowest values when the PDL was not simulated, but had no effect on samples with SPDL.

DISCUSSION

The influence of PDL is often omitted in *in vitro* tests that evaluate post removal using ultrasonic devices, as opposed to other studies that evaluate the *in vitro* fracture resistance of restored teeth. The PDL is an important structure for distributing the stress generated by load application on teeth. Based on this, elastomeric materials have been used to reproduce the PDL in several studies[8,17,21]. Polyether impression material is adequate for such purpose because of its ease of use, consistency and deformation limit[21]. One difficulty of using SPDL in tensile tests is the possibility of it being dislodged during load application. In the present study, roots were fixed in a resin cylinder with two stainless steel wires to prevent dislodgment of root and allow testing. This methodology enabled tensile load application on samples included with SPDL, but it had an influence on the tensile bond strength values.

Samples included in the cylinder with the presence of SPDL presented lower bond strength values than those directly included in resin, when the ultrasonic vibrations were not applied. One possible explanation for this may be related to the forces resulting during tensile load application. During the test, the deformation of wires used to fix the root allowed a slight dislodgement of the root. Lower dislodgement of dowel is expected since there is root movement. Thus, the tensile load is more concentrated at the interface between resin cement and dowel for the samples included with SPDL. This results in the need for lower loads to remove these cast dowel and cores.

Despite this influence on the load distribution, the simulation of PDL also intervened in the effectiveness of the ultrasonic vibration to reduce the dowel retention. The tensile bond strength of the samples included in resin cylinders with SPDL was not altered by use of the ultrasound device, as opposed to samples included without SPDL. Thus, the null hypothesis was rejected. The reduction in cast dowel and core retention with the application of ultrasonic energy has been demonstrated by several studies[1,3,5,7,9,20]. The ultrasonic device used in this study has a piezoelectric transducer that transforms electricity into ultrasonic vibrations. Quartz crystals within the transducer are vibrated by the electricity flowing through them. By applying an alternating electrical field across the crystal, the quartz is compressed and released producing vibration of the tip[4]. These ultrasonic vibrations are transmitted through the dowel and core, fracturing the cement interposed between the dowel and the root canal walls and facilitate their removal.

Several studies has reported that the type of luting agent can influence the post retention and removal procedure[10,11,15]. Posts cemented with resin cements usually require greater force for their removal when compared to those cemented with zinc phosphate or glass ionomer cements[7,10,11,15]. In this study, the cast dowel and cores were luted with the resin cement Panavia F. This cement contains the resin monomer 10-MDP (10-methacryloyloxydecyl di-hydrogen phosphate) in its composition, which bonds to metal oxides[22]. Thus, dowel and core removal is dependent on resin cement fracture. Considering that it is essential for the vibrations to reach the resin cement in order to facilitate dowel and core removal, the root inclusion method may affect the efficacy of the ultrasonic device.

The high rigidity of acrylic resin used for sample inclusion does not allow for root movement during the ultrasound application. Thus, approximately all the energy dispensed by the tip of the ultrasonic device is transmitted through the cast dowel and core to reach the resin cement. On the other hand, the root mobility permitted by impression material may to reduce the energy that reaches the resin cement[21]. Thus, the resin cement was submitted to lower strain, which was not sufficient to reduce the retention of cast dowel and core. The latter situation is closer to clinical reality than directly including the root in resin cylinders. Therefore, within the limitations of this study, it was demonstrated that the PDL simulation had a significant effect on custom cast dowel and core removal with ultrasonic vibrations. This means that several of the *in vitro* studies that evaluated ultrasonic devices for dowel and core removal may have overestimated their efficacy.

CONCLUSION

The ultrasonic vibration had no effect on cast dowel-and-core retention when the PDL was simulated. The present outcomes demonstrate the importance of this simulation during *in vitro* evaluation to avoid overestimating the efficacy of ultrasonic vibration used for cast dowel-and-core removal.

REFERENCES

1- Alfredo E, Garrido AD, Souza-Filho CB, Correr-Sobrinho L, Sousa-Neto MD. *In vitro* evaluation of the effect of core diameter for removing radicular post with ultrasound. J Oral Rehabil. 2004;31:590-4.
2- Bergeron BE, Murchison DF, Schindler WG, Walker WA 3rd. Effect of ultrasonic vibration and various sealer and cement combinations on titanium post removal. J Endod. 2001;27:13-7.
3- Braga NM, Alfredo E, Vansan LP, Fonseca TS, Ferraz JA, Sousa-Neto MD. Efficacy of ultrasound in removal of intraradicular posts using different techniques. J Oral Sci. 2005;47:117-21.

4- Budd JC, Gekelman D, White JM. Temperature rise of the post and on the root surface during ultrasonic post removal. Int Endod J. 2005;38:705-11.
5- Buoncristiani J, Seto BG, Caputo AA. Evaluation of ultrasonic and sonic instruments for intraradicular post removal. J Endod. 1994;20:486-9.
6- Chalfin H, Weseley P, Solomon C. Removal of restorative posts for the purpose of nonsurgical endodontic retreatment: report of cases. J Am Dent Assoc. 1990;120:169-72.
7- Dixon EB, Kaczkowski PJ, Nicholls JI, Harrington GW. Comparison of two ultrasonic instruments for post removal. J Endod. 2002;28:111-5.
8- Dulaimi SF, Wali Al-Hashimi MK. A comparison of spreader penetration depth and load required during lateral condensation in teeth prepared using various root canal preparation techniques. Int Endod J. 2005;38:510-5.
9- Fonseca RG, Dos Santos Cruz CA, Adabo GL, Vaz LG. Comparison of the tensile bond strengths of cast metal crowns luted with resin cements. J Oral Rehabil. 2004;3:1080-4.
10- Garrido AD, Fonseca TS, Alfredo E, Silva-Sousa YT, Sousa-Neto MD. Influence of ultrasound, with and without water spray cooling, on removal of posts cemented with resin or zinc phosphate cements. J Endod. 2004;30:173-6.
11- Habib B, von Fraunhofer JA, Driscoll CF. Comparison of two luting agents used for retention of cast dowel and cores. J Prosthodont. 2005;4:164-9.
12- Hauman CH, Chandler NP, Purton DG. Factors influencing the removal of posts. Int Endod J. 2003;36:687-90.
13- Imura N, Pinheiro ET, Gomes BP, Zaia AA, Ferraz CC, Souza-Filho FJ. The outcome of endodontic treatment: a retrospective study of 2000 cases performed by a specialist. J Endod. 2007;33:1278-82.
14- Johnson WT, Leary JM, Boyer DB. Effect of ultrasonic vibration on post removal in extracted human premolar teeth. J Endod. 1996;22:487-8.
15- Love RM, Purton DG. Retention of posts with resin, glass ionomer and hybrid cements. J Dent. 1998;26:599-602.
16- Peters J, Zyman G, Kogan E, Kuttler S, García-Godoy F. Retention of three endodontic post systems. Am J Dent. 2007;20:198-200.
17- Pişkin B, Aydin B, Sarikanat M. The effect of spreader size on fracture resistance of maxillary incisor roots. Int Endod J. 2008;41:54-9.
18- Poiate IA, Vasconcellos AB, Santana RB, Poiate E. Three-dimensional stress distribution in the human periodontal ligament in masticatory, parafunctional, and trauma loads: finite element analysis. J Periodontol. 2009;80:1859-67.
19- Salvi GE, Siegrist Guldener BE, Amstad T, Joos A, Lang NP. Clinical evaluation of root filled teeth restored with or without post-and-core systems in a specialist practice setting. Int Endod J. 2007;40:209-15.
20- Silva MR, Biffi JC, Mota AS, Fernandes Neto AJ, Neves FD. Evaluation of intracanal post removal using ultrasound. Braz Dent J. 2004;15:119-26.
21- Soares CJ, Pizi EC, Fonseca RB, Martins LR. Influence of root embedment material and periodontal ligament simulation on fracture resistance tests. Braz Oral Res. 2005;19:11-6.
22- Tsuchimoto Y, Yoshida Y, Mine A, Nakamura M, Nishiyama N, Van Meerbeek B, et al. Effect of 4-MET- and 10-MDP-based primers on resin bonding to titanium. Dent Mater J. 2006;25:120-4.