Revista Odonto Ciência
Journal of Dental Science

ORIGINAL ARTICLE

Rev Odonto Cienc 2013; 28(3)
http://revistaseletronicas.pucrs.br/ojs/index.php/fo

Open Access

Cleaning efficacy of hand and rotary instrumentation techniques in oval-shaped root canals: scanning electron microscopic study

Monique Dossena Acauan[a], Amanda Donga[a], Renata Dornelles Morgental[a], Patricia Maria Poli Kopper[b], Simone Bonato Luisi[b], Fabiana Vieira Vier-Pelisser[a]

[a] Department of Endodontics, School of Dentistry, Pontifical Catholic University of Rio Grande do Sul (PUCRS), Porto Alegre, Brazil
[b] Department of Endodontics, School of Dentistry, Federal University of Rio Grande do Sul (UFRGS), Porto Alegre, Brazil

Abstract

Objective: To assess the cleaning efficacy of the Mtwo rotary system, hand instrumentation and their combination in oval-shaped root canals.

Methods: Thirty human mandibular incisors were divided into three groups (G): GMtwo – basic series (10.04, 15.05, 20.06, 25.6) and instruments 30.05, 35.04, 40.04 from complementary series; GMtwo + Hand – basic series of Mtwo followed by sizes 30 to 40 hand instruments; GHand – classic technique with sizes 15 to 40 hand instruments. Teeth were longitudinally sectioned and then the buccal and lingual root canal walls were observed by scanning electron microscopy (SEM). Central images of each canal third were obtained and classified into scores based on the amount of smear layer (SL) and organic debris (OD). Data were analyzed by Kruskal-Wallis and Friedman tests.

Results: There was no significant difference between groups ($P>0.05$) regarding SL. The coronal third showed significantly lower scores than the other segments ($P<0.05$). In regard to OD, GHand scores were significantly lower than GMtwo + Hand ($P<0.05$). There was no significant difference between thirds ($P>0.05$).

Conclusion: None of the techniques were completely effective in cleaning oval-shaped root canals. The apical third was the area with higher amount of SL.

Keywords: Endodontics; root canal preparation; smear layer; scanning electron microscopy

Eficácia de limpeza de técnicas de instrumentação manual e rotatória em canais radiculares ovais: estudo em microscopia eletrônica de varredura

Resumo

Objetivo: Avaliar a eficácia de limpeza do sistema rotatório Mtwo, da instrumentação manual e da associação de ambos em canais radiculares ovais.

Metodologia: Trinta incisivos inferiores humanos foram divididos em três grupos (G): GMtwo – série básica (10.04; 15.05, 20.06, 25.06) e instrumentos 30.05, 35.04, 40.04 da série complementar; GMtwo + Manual – série básica do Mtwo seguida por instrumentos manuais 30 ao 40; GManual – técnica clássica com instrumentos manuais 15 ao 40. Os dentes foram seccionados longitudinalmente e as paredes vestibular e lingual dos canais radiculares foram visualizadas em microscopia eletrônica de varredura (MEV). Imagens centrais de cada terço do canal foram obtidas e classificadas em escores baseados na quantidade de smear layer (SL) e detritos orgânicos (DO). Os dados foram analisados pelos testes de Kruskal-Wallis e Friedman.

Resultados: Não houve diferença significativa entre os grupos ($P>0,05$) quanto à SL. O terço cervical demonstrou escores significativamente menores do que os demais segmentos ($P<0,05$). Quanto aos DO, escores do GManual foram significativamente menores que no GMtwo + Manual ($P<0,05$). Não houve diferença significativa entre os terços ($P>0,05$).

Conclusão: Nenhuma das técnicas foi completamente eficaz na limpeza de canais radiculares ovais. O terço apical foi a área com maior quantidade de SL.

Palavras-chave: Endodontia; preparo do canal radicular; camada de esfregaço; microscopia eletrônica de varredura

Correspondence:
Renata Dornelles Morgental / Fabiana Vieira Vier-Pelisser
remorgental@hotmail.com / endopelisser@gmail.com

Received: November 27, 2012
Accepted: August 21, 2013

Conflict of Interests: The authors state that there are no financial and personal conflicts of interest that could have inappropriately influenced their work.

Copyright: © 2013 Acauan et al.; licensee EDIPUCRS.

This work is licensed under a Creative Commons Attribution-NonCommercial 3.0 Unported (CC BY-NC 3.0).

ISSN: 1980-6523

Introduction

One of the most important phases of endodontic therapy is the chemicomechanical preparation, which is directly related to concomitant disinfection and subsequent obturation. Endodontic instruments should remove dentin and pulp remnants from the root canal walls, creating an environment free of bacteria [1].

The geometric asymmetry between root canals and endodontic preparations has motivated continuous investigation and new instruments have been developed in order to improve root canal system debridement [2-4]. *In vitro* studies indicate that large areas of root canal surface remain untouched after hand and rotary instrumentation [5,6].

Since the late 1980's, with the introduction of nickel-titanium (NiTi) in endodontics, several rotary systems have appeared on the market. NiTi rotary instruments allow rapid root canal preparation with less operative errors in curved root canals [7]. However, many studies show that these instruments produce round preparations [4,8,9], which most often do not coincide with the anatomical shape of the root canal. Oval-shaped canals demonstrate greater difficulty in removing the layer of infected dentin, compared to circular canals [8].

Due to concerns about canals with oval cross-sectional morphology, many techniques have been suggested to facilitate their instrumentation [6,8,9]. Brushing motion, with slight pressure against the root canal walls is one of the most advocated techniques [9].

Wu et al. [6] investigated the ability of two hand techniques, balanced force and circumferential filling, in removing the inner layer of dentin in oval-shaped canals of mandibular incisors. They analyzed microscopic images of the root cross-section obtained before and after preparation. Although the circumferential filling technique has removed greater percentage of dentin, both techniques have left large portions of the canal wall uninstrumented.

Other studies have shown that rotary instrumentation is also not totally effective in cleaning oval-shaped canals [1,4,11]. The apical portion appears to be a critical point, compared to coronal and middle thirds [1,11]. The presence of depression and deep grooves on the dentinal walls in this portion may explain these less-instrumented areas and the accumulation of smear layer [1].

The Mtwo rotary system (VDW, Munich, Germany) has been available since 2005. Its basic series includes instruments 10.04, 15.05, 20.06 and 25.06, with the first and second values corresponding to their tip diameter and taper, respectively. The basic series can be complemented by rotary instruments of the same system (30.05, 35.04 and 40.04) in large root canals, This system has S-shaped cross-section, two active cutting edges, inactive tip and progressive pitch along the instrument shaft [4,10].

Since during hand instrumentation the operator has the opportunity to press the instrument against flattened walls and making use of the advantages of rotary preparation, this study aimed to assess, by SEM, the cleaning efficacy of the Mtwo rotary system, hand instrumentation and their combination in oval-shaped root canals of mandibular incisors.

Methodos

The present study was approved by the Research Ethics Committee of the Pontifical Catholic University of Rio Grande do Sul (protocol number 11/05646). Thirty human mandibular incisors were used. All teeth were radiographed in both mesiodistal and buccolingual views to verify the absence of calcification, root resorption or immature apex. After coronal access, the root canals were irrigated with 1% sodium hypochlorite solution (NaOCl; Biodinâmica, Ibiporã, Brazil) by using a 30G needle and 5 mL syringe (Ultradent, South Jordan, USA). Coronal preflaring was performed with LA Axxess 20.06 bur (SybronEndo, Anaheim, USA) in a low speed handpiece (Kavo, Charlotte, USA). The bur was introduced into the root canal with a continuous movement until resistance.

The working length was visually determined by introducing a size 10 K-file (VDW Endodontic Synergy, Munich, Germany) with a silicon stop into the root canal until its tip was observed at the apical foramen; 1 mm was reduced from that value.

Specimens were embedded in EmBed-812 resin (Electro Microscopy Sciences, Fort Washington, USA) and divided into three experimental groups (G), according to the instrumentation technique used (n=10):

- GMtwo – rotary instrumentation with the basic series of the Mtwo system (VDW Endodontic Synergy, Munich, Germany), which includes the instruments 10.04, 15.05, 20.06 and 25.06, complemented by rotary instruments of the same system (30.05, 35.04 and 40.04);
- GMtwo + Hand – rotary instrumentation with the basic series of the Mtwo system (VDW Endodontic Synergy, Munich, Germany), supplemented with hand instrumentation, using sizes 30, 35 and 40 K-files (VDW Endodontic Synergy, Munich, Germany);
- GHand – classic hand technique with sizes 15 to 40 K-files (VDW Endodontic Synergy, Munich, Germany).

For all groups, instruments were employed with brushing movements toward the buccal and lingual root canal walls. Time for using each instrument was set in 15 seconds. Irrigation was performed with NaOCl, as previously described, using 2 mL of irrigating solution at every exchange of instrument. As final irrigation protocol, the root canals were flushed with 5 mL of 17% EDTA (Biodinâmica, Ibiporã, Brazil), which was agitated with a size #40 hand file for 3 minutes. Then, root canals were irrigated with 5 mL of saline solution in order to remove EDTA residue.

Resin blocks containing the teeth were sectioned in thirds: 0-3 mm (apical), 3-6 mm (middle) and 6-9 mm (coronal). Root segments were then longitudinally sectioned for analysis of root canal walls cleanliness. These procedures were

performed by a double-sided diamond disc (911H–Komet Brasseler, Düsserdorf, Germany) in low speed. The segments were placed in containers with specific codes according to the teeth number (1-30) and root segment (A to apical, M to middle and C to coronal).

One half of each third was randomly selected to be analyzed by SEM (Philips XL 30; Philips, Eindhoven, Netherlands). Specimens were subjected to sequential changes of acetone (Synth, Diadema, Brazil) into ascending concentrations (30%, 50%, 70% and 90% for 10 min; 90% for 20 min, 100% for 10 and 20 min). Subsequently, they were fixed on aluminum stubs with double sided adhesive and coated with approximately 30 nm of gold (Sputter coater SCD 050, Bal-Tec, Germany).

Two images of each third were obtained at 1 mm and 2 mm from the coronal edge in the root canal center with ×2000 magnification. The evaluation of root canal walls cleanliness followed the criteria described by Foschi et al. [1] and Prati et al. [11], regarding smear layer (SL) and organic debris (OD), as shown in Table 1 and Figure 1.

An experienced and calibrated (Kappa = 0.741 for SL, 0.789 for OD, P<0.05) examiner performed all readings. Kruskal-Wallis test, followed by Dunn test, was applied to compare the instrumentation techniques. Root canal thirds were compared by Friedman test at a significance level of 5%.

Results

The results for SL are shown in Table 2. There was no significant difference between groups (P>0.05), although hand preparation has shown lower scores, ie less amount of SL, compared to the two techniques with the Mtwo rotary system. In general, the coronal portion presented significantly lower scores than the other thirds (P<0.05).

Table 3 shows the results for OD. General comparison showed that GHand scores were significantly lower than GMtwo + Hand scores (P<0.05). However, when the apical third was singly analyzed, there was no significant difference between groups. Moreover, there was no significant difference between thirds (P>0.05).

Table 1. Criteria used to classify cleaning efficacy. Adapted from Foschi et al. [1] and Prati et al. [11].

	1	2	3	4
Smear layer	Absent, more than 75% of tubules exposed and free from smear layer	Present in limited areas, less than 75% of tubules uncovered	Present, tubules visible in limited areas and partially closed	Homogeneous smear layer present above all dentin
	Tubules completely open	Tubules partially open	Less than 50% of dentinal tubules visible	Dentinal tubules not visible
Organic debris	Absent	Minimal presence of pulpal-fibrous debris	Partial presence of pulpal-fibrous debris	Presence of an organized collagenous matrix

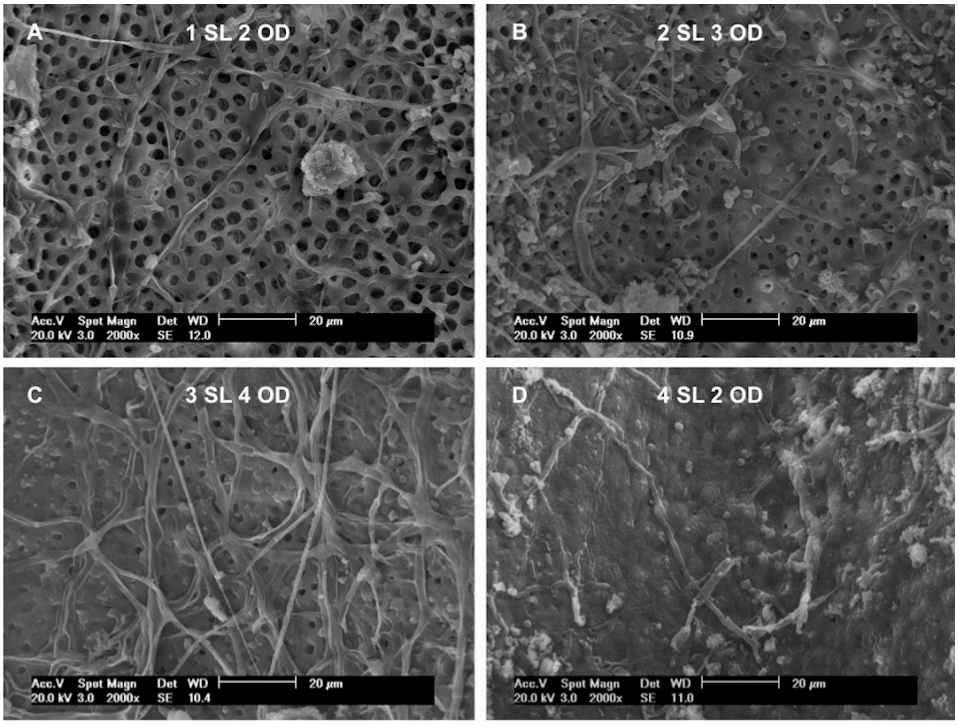

Fig. 1. SEM images with respective scores for smear layer (SL) and organic debris (OD):
A. SL virtually absent, with almost 100% of open tubules and minimal presence of OD;
B. Less than 75% of open tubules and partial presence of OD;
C. visible dentinal tubules in limited areas and presence of an organized matrix of OD;
D. no visible dentinal tubules and minimal presence of OD.

Table 2. Scores of smear layer (mean and standard deviation) for different experimental groups and root canal thirds.

	Smear layer			
	Coronal	Middle	Apical	General
GMtwo	2.50±0.82 $^{a\,A}$	2.85±0.98 $^{a\,AB}$	3.40±0.75 $^{a\,B}$	2.91±0.92 ^{a}
GMtTwo + Hand	2.61±0.77 $^{a\,A}$	3.44±0.61 $^{a\,B}$	3.77±0.42 $^{a\,B}$	3.20±0.87 ^{a}
GHand	2,00±1.03 $^{a\,A}$	2.62±1.25 $^{a\,AB}$	3.25±1.06 $^{a\,B}$	2.71±1.21 ^{a}
General	2.38±0.89 ^{A}	2.98±1.01 ^{B}	3.48±0.79 ^{B}	

Same lowercase letters in columns indicate no statistically significant difference between groups ($P<0.05$).Same capital letters in rows indicate no statistically significant difference between root thirds ($P<0.05$).

Table 3. Scores of organic debris (mean and standard deviation) for different experimental groups and root canal thirds.

	Organic debris			
	Coronal	Middle	Apical	General
GMtwo	3.15±0.81 $^{ab\,A}$	3.05±0.94 $^{ab\,A}$	2.80±0.95 $^{a\,A}$	3.00±0.90 ^{ab}
GMtwo + Hand	3.61±0.60 $^{a\,A}$	3.38±0.77 $^{a\,A}$	2.94±1.05 $^{a\,A}$	3.25±0.90 ^{a}
GHand	2.43±1.09 $^{b\,A}$	2.43±1.03 $^{b\,A}$	3.00±1.09 $^{a\,A}$	2.67±1.11 ^{b}
General	3.09 ± 0.95 ^{A}	2.98 ± 0.98 ^{A}	2.90 ± 1.01 ^{A}	

Same lowercase letters in columns indicate no statistically significant difference between groups ($P<0.05$). Same capital letters in rows indicate no statistically significant difference between root thirds ($P<0.05$).

Discussion

The goals of endodontic instrumentation include adequate debridement and disinfection of the root canal system [12]. However, we can rarely obtain totally clean root canals (2,3,8,9,13), especially when dealing with oval cross-sections [4,8,14,15].

Investigations conducted with hand and rotary instrumentation showed that both techniques are incapable of promoting complete walls cleanliness in oval-shaped root canals (4,6). Rotary instruments, despite their greater taper, as occurs in the Mtwo system, have difficulty in preparing the buccal and lingual/palatal walls in these situations [13], as they tend to produce circular preparations [4,8,16]. The present study suggested the association of two techniques in order to improve cleaning efficacy, as this would combine tapered preparations with hand movements against the root canal walls.

As parameters for evaluating root canal cleanliness, we chose to observe the presence of smear layer and organic debris on the dentinal walls. Their permanence inside the root canal after chemomechanical preparation may reduce the adaptation of filling materials and provide means for microorganism colonization [17].

Smear layer is produced by endodontic instrumentation and its composition includes inorganic debris, collagen, pulp remnants and bacteria [14,18-20]. Organic debris, on the other hand, comprises mainly remaining pulpal tissue that is loosely attached to the dentinal walls. Its presence may point out areas that were not touched by instruments [20]. SEM is a suitable method for investigating the effect of endodontic instruments on the dentinal surface, producing high-resolution images with increased magnification [1,11,12].

The present study found lower amount of smear layer and organic debris in the root canals prepared by hand technique, compared to rotary instrumentation, although the difference was not statistically significant. The best performance of hand instruments may be explained by the ease of performing brushing movements against the buccal and lingual walls. The combination of rotary and hand techniques, performed in this study, showed no improvement in cleaning oval-shaped canals as we could expect.

In regard to root segments, our results showed the difficulty in cleaning the apical third, where we found higher amounts of smear layer compared to the other thirds, as described in previous studies [1,11]. As the root canal approaches the apex, the flattened cross-section gives place to a round format with smaller diameter [21], thus there is increased contact between the instruments and the dentinal walls, generating more smear layer. Furthermore, the access for irrigating and chelating solutions is limited and smear layer removal becomes difficult.

In general, the presence of organic debris proved to be lower in the apical third, but no significant different was detected. Again, the circular cross-section in this area may explain the results. Other researchers have observed greater presence of debris in the apical portion [1,11], justified by the presence of irregularities and grooves on the dentinal walls, which would impair cleaning efficacy. It is important to note that Prati et al. [11] used maxillary incisors, while Foshi et al. [1] utilized maxillary incisors, canines and premolars. Also, the last instrument employed in their studies had smaller tip diameter compared to the groups used in our research.

Although better cleaning efficacy was verified when using hand instrumentation, there was still large amount of smear layer and organic debris on the buccal and lingual root canal walls. These findings clearly point out the necessity of other methods to achieve proper cleanliness. In the present study, conventional irrigation was performed with NaOCl and EDTA, which act on the dissolution of organic matter

and smear layer removal, respectively [22], but were not sufficient to promote clean root canal walls.

Alternative irrigation techniques and devices, such as passive ultrasonic irrigation (PUI) and the EndoVac system (Discus Dental, Culver City, USA), have been developed to improve cleaning efficacy especially in the apical third [23]. PUI activates the irrigant without instrumenting the dentinal walls. The EndoVac system combines the use of macro and micro cannulas that produce large pressure difference and hence vacuum inside the root canal. Both methods allow fast movement and continuous renewal of the irrigating solution [24]. Studies have shown the efficacy of these techniques in the apical area [23,25], promoting the reflux of debris accumulated at that location and also along the entire length of the buccal and lingual walls of flattened canals [24] compared to conventional irrigation.

Although SEM proved to be an effective method for assessing root canal wall cleanliness [1,11], this methodology does not allow the visualization of the root canal cross-section before and after preparation and hence the shaping ability of each instrumentation technique. Thus, further researches are necessary approaching the combination of rotary and hand instrumentation techniques, using others methodologies as optical microscopy and tomographic images, in order to obtain more conclusive results. Moreover, other rotary systems and sequences must be evaluated.

Conclusions

None of the techniques were completely effective in cleaning oval-shaped root canals. In general, the apical third showed the highest amount of smear layer, compared to coronal and middle segments. In regard to organic debris, no significant difference was detected between thirds.

References

1. Foschi F, Nucci C, Montebugnoli L, Marchionni S, Breschi L, Malagnino VA, Prati C. SEM evaluation of canal wall dentine following use of Mtwo and ProTaper NiTi rotary instruments. Int Endod J 2004;37:832-9.
2. Rödig T, Hülsmann M, Kahlmeier C. Comparison of root canal preparation with two rotary NiTi instruments: ProFile .04 and GT rotary. Int Endod J 2007; 40:553-62.
3. Uzun O, Topuz O, Aydyn C, Alacam T, Aslan B. Enlarging characteristics of four nickel-titanium rotary instrument systems under standardized conditions of operator-related variables. J Endod 2007; 33:1117-20.
4. Elayouti A, Chu AL, Kimionis I, Klein C, Weiger R, Löst C. Efficacy of rotary instruments with greater taper in preparing oval root canals. Int Endod J 2008; 41:1088-92.
5. Yang G, Yuan G, Yun X, Zhou X, Liu B, Wu H. Effects of two nickel-titanium instrument systems, Mtwo versus ProTaper Universal, on root canal geometry assessed by micro-computed tomography. J Endod 2011;37:1412-6.
6. Wu MK, van der Sluis LW, Wesselink PR. The capability of two hand instrumentation techniques to remove the inner layer of dentine in oval canals. Int Endod J 2003;36:218-24.
7. Peters OA, Paqué F. Current developments in rotary root canal instrument technology and clinical use: a review. Quintessence Int 2010;41: 479-88.
8. Wu MK, Wesselink PR. A primary observation on the preparation and obturation of oval canals. Int Endod J 2001;34:137-41.
9. Weiger R, ElAyouti A. Efficiency of hand and rotary instruments in shaping oval root canals. J Endod 2002;28:580-3.
10. Xu X, Eng M, Zheng Y, Eng D. Comparative study of torsional and bending properties for six models of nickel-titanium root canal instruments with different cross-sections. J Endod 2006;32:372-5.
11. Prati C, Foschi F, Nucci C, Montebugnoli L, Marchionni S. Appearance of the root canal walls after preparationwith NiTi rotary instruments: a comparative SEM investigation. Clin Oral Invest 2004;8:102-10.
12. Albrecht LJ, Baumgartner JC, Marshall JG. Evaluation of apical debris removal using various sizes and tapers of ProFile GT files. J Endod 2004;30:425-8.
13. Rödig T, Hülsmann M, Mü hge M, Schäfers F. Quality of preparation of oval distal root canals in mandibular molars using nickel-titanium instruments. Int Endod J 2002;35:919-28.
14. Paqué F, Balmer M, Attin T, Peters OA. Preparation of oval-shaped root canals in mandibular molars using NiTi rotary instruments. J Endod 2010;36:703-7.
15. Lumley PJ, Walmsley AD, Walton RE, Rippin JW. Cleaning of oval canals using ultrasonic or sonic instrumentation. J Endod 1993;19:453-7.
16. Hülsmann M, Schade M, Schäfers F.Acomparative study of root canal preparation with HERO 642 and Quantec SC rotary NiTi instruments. Int Endod J 2001;34:538-46.
17. Bowman CJ, Baumgartner JC. Gutta-percha obturation of lateral grooves and depressions. J Endod 2002;28:220-3.
18. Mader CL, Baumgartner JC, Peters DD. Scanning electron microscopic investigation of the smeared layer on root canal walls. J Endod 1984;10:477-83.
19. Pashley DH, Tao L, Boyd L, King GE, Horner JA. Scanning electron microscopy of the substructure of smear layers in human dentine. Arch Oral Biol 1988; 33:265-70.
20. Bürklein S, Hiller C, Huda M, Schäfer E. Shaping ability and cleaning effectiveness of Mtwo versus coated and uncoated EasyShape instruments in severely curved root canals of extracted teeth. Int Endod J 2011;44:447-57.
21. Wu MK, Róris A, Barkis D, Wesselink PR. Prevalence and extent of long oval canals in the apical third. Oral Sur Oral Med Oral Pathol Oral Radiol Endod 2000;89:739-43.
22. Bystrom A, Sundqvist G. The antibacterial action of sodium hypochlorite and EDTA in 60 cases of endodontic therapy. Int Endod J 1985;18: 35-40.
23. Gu L, Kim JR, Ling J, Choi KK, Pashley DH, Tay FR. Review of contemporary irrigant agitation techniques and devices. J Endod 2009;35:791-804.
24. Ribeiro EM, Silva-Souza YTC, Souza-Gebriel AE, Souza-Neto MD, Lorencetti KT, Silva SRC. Debris and smear removal in flattened root canals after use of different irrigant agitation protocols. Microsc Res Tech 2012;75:781-90.
25. Castelo-Baz P, Martín-Biedma B, Cantatore G, Ruíz-Piñon M, Bahillo J, Rivas-Mudiña B, Varela-Patiño P. In vitro comparison of passive and continuous ultrasonic irrigation in simulated lateral canals of extracted teeth. J Endod 2012; 38:688-91.