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Original Article

Evaluation of apical extrusion of debris during retreatment: R-Endo rotary instruments versus hand files

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Abstract

Aim: The aim of this ex vivo study was to compare the amount of debris extruded during retreatment using stainless steel hand files (Hedstroem files) and R-Endo Nickel Titanium rotary instruments.
Methodology: Eighty single-rooted freshly extracted human mandibular premolars were divided into two groups consisting of 40 teeth each. Retreatment was performed with R-Endo (Micro-Mega, Besançon, France) and Hedstroem files (Dentsply, Maillefer, Ballaigeus, Switzerland). The experimental teeth were obturated with lateral condensation technique. Then, 1.5-mL Eppendorf tubes were used to collecting the material that was extruded during preparation by subtracting post-instrumentation weight from pre-instrumentation weight.
Results: There were significant differences in the amount of debris extruded between the groups ($p<0.001$). The amount of apical extrusion in the R-Endo group was determined to be less than in the hand instrumentation group.
Conclusion: Within the limitations of this study, it might be concluded that all tested instruments resulted in apical extrusion of debris. During endodontic retreatment procedures, the hand files extruded a significantly higher amount of debris than the R-Endo.

Keywords: Apical extrusion, retreatment, nickel-titanium files, R-endo file, hand file

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Introduction

Non-surgical retreatment, surgical retreatment or tooth extraction are among the treatment options for teeth with failed root canal treatment (1, 2). However non-surgical retreatment is a generally accepted conservative approach for the management of these compromised teeth (3).

The goals of the retreatment process are removing old canal filling from the root canal completely, reshaping and disinfecting the root canal, and performing a hermetic root canal filling (4, 5).

During retreatment, hand tools and solvents (6, 7), Ni-Ti rotary instrument systems (8, 9), heat-carrier systems (10, 11), laser (12), and ultrasonic instruments (13, 14) are used for removing the previous canal fillings. Currently, Ni-Ti rotary instrument systems are being used for a more favorable completion of the retreatment procedure, and various systems have been developed to reach this purpose. Studies have concluded that these systems are effective, safe (7, 15) and fast (9, 16) to remove previous root canal fillings.

Studies have shown that all techniques caused the extrusion of debris from apical foramen into the periradicular tissues while shaping the root canals (17, 18). This extrusion material, specifically if infected, may result in adverse biological responses in the periapical tissues by disturbing the balance between host and microbial flora, initiate inflammatory events, cause acute exacerbations, or delay the apical healing process (19, 20). It was also shown that non-contaminated intracanal material may also trigger an inflammatory periapical response (21).

It has further been demonstrated that the techniques involving a push-pull motion tend to produce more apical extrusion compared to rotation techniques (22-24).

A nickel-titanium rotary instrument system, R-Endo (Micro Mega, Besançon France) was developed for retreatment procedures. These instruments have a triangular cross-section with a positive cutting angle. There is no active tip or radial land. The design of R-Endo entails a wider area compared to round sectional Hedstroem files to serve as storage for the ingredients of the waste products (16).

The aim of this study is to compare the retreatment processes with R-Endo and traditional hand files in terms of both extrusion debris from the apical and to evaluate the required time for the removal of gutta-percha.

Materials and Methods

This study was approved by the Istanbul University Faculty of Dentistry Research Ethics Committee protocol number 2009/1799 in terms of the study methods and protocols. Moreover, data collection was started after an informed consent form was signed by each patient.

A total of eighty freshly extracted single rooted human mandibular premolars with mature apices were included in the present study. The experimental teeth were examined by radiographs in the buccal and proximal directions, and the degree of canal curvature was determined according to Schneider's method (24). Teeth with calcification, with curvatures greater than 100 and with open apices were excluded from the study. The lengths of roots were in the range of 17±1 mm. Only root canals with 10 apical diameter size were selected.

To examine the patency of the apical diameter, a #10 K-file (Dentsply, Maillefer, Ballaigeus, Switzerland) was placed deep into the root canal until the tip of the file was visible at the apical foramen and then withdrawn 1 mm to determine the working lengths. Thus, a standardization was made with respect to apical foramen size. The root canals were prepared using K-files and Gates-Glidden burs with the step-back technique. Then, instrumentation was standardized with a #30 K-file, reaching the full working length and final coronal flaring with Gates-Glidden burs of sizes two and three. A #15 K-file was used during root canal preparation to maintain the patency of the canal. After each instrument, the canals were irrigated with 2 mL of 2.5% NaOCl solution. When instrumentation of the root canals was completed, a final rinse with 17% EDTA was conducted for 1 min to remove the smear layer.

The root canals were dried with paper points and filled with the lateral compaction technique using gutta-percha (DiaDent, Korea) and sealer (AH-Plus, Dentsply) that was mixed according to the manufacturer's instructions. The coronal access cavities were sealed with a temporary filling material (Cavit-G, 3M ESPE, Seefeld, Germany). All teeth were stored in an incubator with 100% humidity at 37°C for 30 days to allow the sealer to set completely.

The method described by Ferraz et al. was used to measure the volume of irrigant and the weight of apically extruded debris during the retreatment procedure (22). The teeth were forced through a hole in a rubber stopper. Before canal instrumentation, Eppendorf tubes were individually weighed on an electrical balance with an accuracy of 0.00001 g (Radwag Instruments, Istanbul, Turkey) and then placed into a 7-mL vial. During the measurement of empty Eppendorf tubes, three consecutive readings were taken, and the average value was recorded. The rubber stopper with the tooth was then fitted into the mouth of the vial. The apical part of the root canal was suspended within the Eppendorf tube, which acted as a collecting container for apical debris and irrigant extruded through the foramen of the root. The vial was vented with a 25-gauge needle along the rubber stopper during instrumentation to equalize the air pressure inside and outside the vial (Fig. 1).

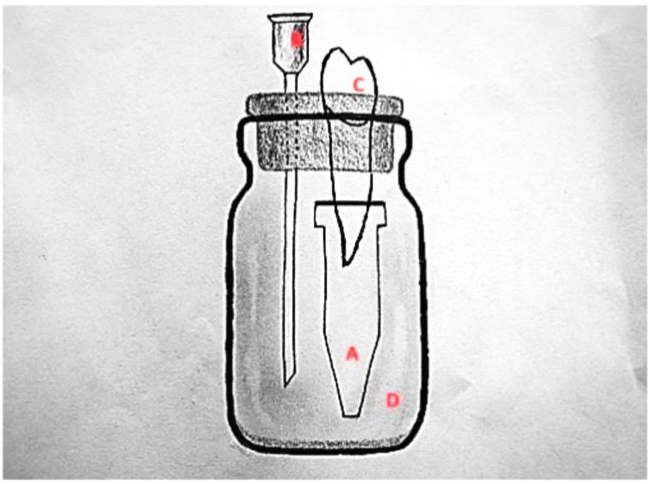

Figure 1. A-Eppendorf tube, B-25 gauge needle, C-Tooth, D-Vial

Retreatment Techniques

The prepared teeth were randomly divided into two groups of 40 specimens each, and the temporary fillings were removed. The root canal filling material was removed by using one of the following techniques for each group.

Group 1: Stainless steel hand files group

The gutta-percha was removed from the coronal portion with Endoflare (Micro-Mega, Besançon, France). This instrument was mounted on an electric motor (VDW Silver, VDW, Munich, Germany) rotating at 450 rpm and with 30 N cm2 torque. The Endoflare instrument was placed in the root canal with a maximal depth of 3 mm. Chloroform solvent was used in both groups. Chloroform was only applied to the coronal and middle 1/3 section of the root canal, then was placed in the root canal to soften the gutta-percha. Hand instrumentation was carried out with Hedstroem files (sizes 15-30) in a circumferential motion. A size-30 H-type file was then introduced into the root canal by using the crown-down technique until the working length was reached with a size-10 H-type file. A step-back procedure with Hedstroem files was then completed with a size-30 file.

Group 2: R-Endo Retreatment Instruments Group

Endoflare (Micro-Mega, Besançon, France) was used as in Group 1 to remove the gutta-percha from the corona. Chloroform was then placed into the root canal to soften the gutta-percha. R-Endo instruments were used with an electric motor (VDW Silver, VDW, Munich, Germany) rotating at 300 rpm with 80 N cm2 torque according to the manufacturer's instructions. R-Endo instruments were used with an inget-type handpiece (Inget, Micro-Mega, Besançon, France) and manipulated in a gentle in-and-out motion. The Re instrument (0.12 Taper) and R1 instrument (0.08 Taper) were used in the coronal thirds of the canal. The R2 instrument (size 25, 0.06 Taper) was used in the middle third of the canal. Finally, the R3 (size 25, 0.04 Taper) and Rs (size 30, 0.04 Taper) instruments were used to the full length of the canal. On withdrawal, the files were cleansed of any obturating material before being reintroduced to the root canal. All instruments were used only once. Irrigation with 2 mL of 2.5% NaOCl was performed during the procedure at each change of the instrument. Gutta-percha removal was deemed to have been completed when the working length was reached, and no more gutta-percha could be removed with the instruments used. To standardize the procedure throughout the study, all teeth were instrumented by a single operator. The retreatment time taken to reach working length (T1) and time for gutta-percha removal (T2) were measured with a stopwatch for each sample. Total time required was calculated in minutes and seconds, including the instrument change and irrigating procedures.

After the retreatment procedure, debris adhering to the outer surface of the roots was collected by washing off the apex with 0.5 mL of distilled water in the Eppendorf tubes. The Eppendorf tubes were stored in an incubator at 68°C for five days to evaporate the moisture before weighing the dry debris. Weighing was carried out on an electric balance with an accuracy of 0.00001 g. Three consecutive readings were noted for each sample, and the average value was recorded. The post-retreatment weights of the tubes were subtracted from the pre-treatment weights determined for the extruded amount of debris.

Statistical analysis

The mean weight of extruded debris for each group was analyzed statistically using SPSS V23 software (SPSS Inc., Chicago, IL, USA), and the Student's t-test was used to compare the two groups. A p-value of less than 0.05 was considered to indicate a statistically significant difference.

Results

Data regarding the weight of debris extruded and total time for retreatment are presented in Tables 1 and 2, respectively. The results indicate that the instruments tested caused measurable apical extrusion of debris. Apical debris extrusion in the R-Endo group was statistically significantly less than in the hand instrumentation group ($p < 0.001$). The R-Endo group required less time to reach the working length and also less time for gutta-percha removal compared to the hand instruments group. There was a statistically significant difference between the groups. In the hand files group, T1 and T2 times were significantly longer than in the R-Endo group ($p < 0.001$).

Table 1. Weight of dry debris extruded apically during cleaning and shaping by each technique

Techniques	Minimum	Maximum	Mean Extrusion (g) ±SD	p-value
Hand Files	0.0006	0.05111	0.01921 ± 0.01433	0.001*
R-Endo	0.00067	0.01187	0.00733 ± 0.00371	

* Mean differences between the two groups are statistically significant ($p<0.001$).

Table 2. Time needed for complete removal of filling material

Techniques	T1 time Mean± SD (min)	T2 time Mean± SD (min)	T1 + T2 total time Mean± SD (min)	p-value
Hand Files	4.05 ± 0.46*	4.44 ± 0.08*	8,49 ± 0.48	0.001*
R-Endo	2.49 ± 0.07	2.02 ± 0.27	4.52 ± 0.29	

* T1 and T2 times in the hand files group were significantly longer than the R-Endo group (p<0.001).

Discussion

Many researchers have evaluated the issue of apically extruded debris from different perspectives, such as the use of step-back vs. crown-down technique (17, 25, 26), instruments type and size (25), the diameter of apical patency (27), preparation endpoint (25), type and amount of irrigation solution (1, 28). Apical extrusion of debris and irrigants has been a topic of specific interest because of its clinical relevance. Apical extrusion may be responsible for postoperative pain or flare-ups, as a result of the introduction of bacteria, pulpal tissue, and irrigating solutions into the periapical tissues (21); therefore, this phenomenon has gathered the attention of many authors. A general consensus reached by studies pertaining to apical extrusion is that rotary instruments that are connected to handpieces via a single motor cause less extruded debris than hand files, regardless of their designs and alloys (17, 23, 29). It is widely accepted that dentine cutting movements of canal instruments are the main cause of this situation. Reddy and Hicks report that the step-back method with forward-backward movement causes more extruded debris than the Lightspeed (Lightspeed Technology Inc.; San Antonio TX), Profile .04 Taper Series 29 (Tulsa Dental Products, Tulsa, OK), and balanced force methods (23). The same researchers have reported that there is no statistically significant difference between the 'balanced force' method that engages hand files with rotational movement and Ni-Ti rotary systems. These findings suggest that the extruded debris is directly affected by the type of procedure rather than the shape and design of the instrument. This could be one of the reasons that R-Endo causes significantly less extruded debris than the Hedstroem files (p<0.001).

Many researchers have reported that Ni-Ti rotary instrument systems cause less extruded debris than hand files (22, 23, 30). The reason for such a result has been explained as the ability of Ni-Ti instruments to remove the canal filling in big pieces through the coronal section of the canal, whereas hand files perform the procedure in small pieces (23). Variation of instrument design might be another reason why R-Endo causes less extruded debris than the Hedstroem files. In terms of waste material storage, the design of R-Endo with a triangular cross-section and positive cutting angle has a wider area compared to the circular cross-section of Hedstroem files. Thus, the waste materials can be eliminated from the root canal by being entrapped in the spaces between the triangular cross-sectional files into the blades instead of being pushed in the apical direction (16).

Fairbourn et al. demonstrated that there was a greater amount of debris extrusion when the canals were instrumented to a length beyond the apical foramen compared to 1 mm short of the foramen; however, the difference was reported to be statistically insignificant (31). Al-Omari and Dummer, McKendry, Beeson et al. found no significant correlation between the working length and the amount of the debris extruded (25, 30, 32). By contrast, Van de Visse, Myers and Montgomery, found that there was a correlation between working length and debris extruded (17, 33). In this study, like many other studies (25, 30, 32), instrumentation was confined to 1 mm short of the apical foramen.

In studies that examine the amount of debris extrusion, root canals were irrigated with NaOCl (23, 30). In the present study, we preferred the most frequently used solution of 2.5% NaOCl. Regarding the amount of irrigation solution, researchers have preferred different alternatives (17, 23, 30). Increasing the amount of irrigation solution can cause a greater amount of debris extrusion (34). In the present study, a total of 20 mL of irrigation solution was used for each tooth, so the effect of this factor could be standardized.

Within the limitations of this ex vivo study, it was concluded that both instrumentation techniques produced a measurable amount of apically extruded debris. These results are consistent with findings reporting that regardless of the techniques and instruments, extrusion of debris is a natural consequence of root canal preparation techniques (7, 8, 28).

Because #30 (Rs) is the final instrument size that can be used in the R-Endo system, the final apical file used on the experimental teeth was #30, and, in accordance with this final preparation, the teeth were filled using #30 gutta-percha cones. During retreatment, the canals were enlarged until a size # 30 at the working length. Thus, a standardization was made. McKendry found that there was no correlation between the apical preparation size and the debris extruded (25). The minimum apical preparation that allowed an efficient irrigation was achieved with a # 30 file. This final size was also a proper apical preparation that is generally made in clinical conditions; clinical situations were simulated by selecting such an apical file size.

In some previous studies, rotary Ni-Ti instruments required less time for gutta-percha removal compared to hand instruments (9, 15, 16, 35, 36).

In a study by Taşdemir et al., which compared the ProTaper (Dentsply Tulsa Dental Specialities, Tulsa, OK, USA), R-Endo, Mtwo (VDW, Munich, Germany) and Hedstreom hand files, it was found that R-Endo required less time for gutta-percha removal than hand instruments (16). The authors commented that this situation could occur due to differences in the design of the instruments. Hülsmann and Bluhm explained that in this situation, gutta-percha was plasticized after rotation of the file (15). Betti and Bramante reported that it was easier to ensure penetration into the softened gutta-percha (8).

In the present study, T1 and T2 times in the R-Endo group were significantly shorter than in the hand files group, which showed similarity with other studies ($p < 0.001$).

Özçopur et al. reported that total time of retreatment varied between four and seven minutes which was calculated during instrument exchange and irrigating procedures (37). Oliveira et al. determined that total time of retreatment was two to four minutes, which did not include the instrument exchange and irrigating procedures (38). Hassanloo et al. reported that the required time for retreatment was 9-13 minutes and that the differences between time periods mentioned in studies may result from the use of different preparation techniques, canal filling materials, apical preparation sizes, differences in the tooth types, researchers' capabilities and use of solvents or burs to facilitate entrance to the canal (39).

In similar studies, a cannula was used to equalize the air pressure inside and outside the vial (17, 18, 22). However, in normal or pathological periapical tissues, apex pressure may be positive or negative (36). No attempt was made to simulate the presence of vital pulp or periapical tissues, and an in vivo model might give different results, as periapical tissues may serve as a natural barrier, inhibiting debris extrusion (40). In this context, the results of experimental studies show that the incidence of postoperative pain may be more than evaluated. In light of this information, working models of experimental and clinical conditions are not compatible with each other. In contrast, studies that report the amount of extruded debris do not reflect the clinical situation precisely, but these studies allow us to observe and measure the effects of variables such as shaping, cleaning, and irrigation methods.

Conclusions

This ex vivo study concluded that during retreatment, both R-Endo Ni-Ti rotary instruments and stainless steel Hedstroem files produced apically extruded debris; however, the amount of extruded dry debris was found to be statistically significantly lower for the R-Endo group. Time required to reach the working length and to remove the gutta-percha was less for the R-Endo group. It should be noted that ex vivo studies may not reflect true clinical outcomes; hence, further studies that incorporate a better resemblance of clinical circumstances may yield more credible information.

Ethical Approval: Ethics committee approval was received for this study from İstanbul University, Faculty of Dentistry Research Ethics Committee, in accordance with the World Medical Association Declaration of Helsinki, with the approval number: 2009/1799.

Peer-review: Externally peer-reviewed.

Author Contributions: Conception – N.Y.A.; Design – N.Y.A., F.H.; Supervision – F.H.; Materials – N.Y.A., C.V.; Data Collection and/or Processing – A.S., N.Y.A., C.V.; Analysis and/or Interpretation – N.Y.A., F.H.; Literature Review – N.Y.A., C.V.; Writer – N.Y.A.; Critical Review –F.H.

Conflict of Interest: No conflict of interest was declared by the authors.

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References

1. Aryanpour S, Van Nieuwenhuysen JP, D'Hoore W. Endodontic retreatment decisions: no consensus. Int Endod J. 2000;33(3):208-18. (Crossref)
2. Kvist T. Endodontic retreatment. Aspects of decision making and clinical outcome. Swed Dent J Suppl. 2001(144):1-57.
3. PE L. Endodontic retreatment. Dent Clin North Am. 1992;36:473-90. (Crossref)
4. Mandel E, Friedman S. Endodontic retreatment: a rational approach to root canal reinstrumentation. J Endod. 1992;18(11):565-9. (Crossref)
5. Stabholz A, Friedman S. Endodontic retreatment--case selection and technique. Part 2: Treatment planning for retreatment. J Endod. 1988;14(12):607-14. (Crossref)
6. Imura N, Kato AS, Hata GI, Uemura M, Toda T, Weine F. A comparison of the relative efficacies of four hand and rotary instrumentation techniques during endodontic retreatment. Int Endod J. 2000;33(4):361-6. (Crossref)
7. Schirrmeister JF, Wrbas KT, Schneider FH, Altenburger MJ, Hellwig E. Effectiveness of a hand file and three nickel-titanium rotary instruments for removing gutta-percha in curved root canals during retreatment. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2006;101(4):542-7. (Crossref)
8. Betti LV, Bramante CM. Quantec SC rotary instruments versus hand files for gutta-percha removal in root canal retreatment. Int Endod J. 2001;34(7):514-9. (Crossref)
9. Saad AY, Al-Hadlaq SM, Al-Katheeri NH. Efficacy of two rotary NiTi instruments in the removal of Gutta-Percha during root canal retreatment. J Endod. 2007;33(1):38-41. (Crossref)
10. Friedman S, Stabholz A, Tamse A. Endodontic retreatment--case selection and technique. 3. Retreatment techniques. J Endod. 1990;16(11):543-9. (Crossref)
11. Friedman S, Mor C. The success of endodontic therapy--

healing and functionality. J Calif Dent Assoc. 2004;32(6):493-503.
12. Farge P, Nahas P, Bonin P. In vitro study of a Nd:YAP laser in endodontic retreatment. J Endod. 1998;24(5):359-63. (Crossref)
13. Jeng HW, ElDeeb ME. Removal of hard paste fillings from the root canal by ultrasonic instrumentation. J Endod. 1987;13(6):295-8. (Crossref)
14. Ladley RW, Campbell AD, Hicks ML, Li S-H. Effectiveness of halothane used with ultrasonic or hand instrumentation to remove gutta-percha from the root canal. Journal of Endodontics. 1991;17(5):221-4. (Crossref)
15. Hülsmann M, Bluhm V. Efficacy, cleaning ability and safety of different rotary NiTi instruments in root canal retreatment. International Endodontic Journal. 2004;37(7):468-76. (Crossref)
16. Taşdemir T, Er K, Yildirim T, Celik D. Efficacy of three rotary NiTi instruments in removing gutta-percha from root canals. International Endodontic Journal. 2008;41(3):191-6. (Crossref)
17. Myers GL, Montgomery S. A comparison of weights of debris extruded apically by conventional filing and Canal Master techniques. Journal of endodontics. 1991;17(6):275-9. (Crossref)
18. Sarıçam E, Altunkaynak B, Kayaoğlu G. ProTaper Retreatment system versus balanced force technique for apical extrusion and gutta-percha removal. Int Dent Res 2019;9(2):63-8. (Crossref)
19. Sundqvist G, Figdor D, Persson S, Sjögren U. Microbiologic analysis of teeth with failed endodontic treatment and the outcome of conservative re-treatment. Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology. 1998;85(1):86-93. (Crossref)
20. Siqueira Jr J. Microbial causes of endodontic flare-ups. International Endodontic Journal. 2003;36(7):453-63. (Crossref)
21. Çelik N, Kaya S, Adıgüzel Ö. Comparing the effect of Reciproc R25 rotary file system on the amount of apical extrusion of debris via using it with different reciprocal angles. Int Dent Res 2021;11(Suppl.1):63-6. (Crossref)
22. Ferraz C, Gomes N, Gomes B, Zaia A, Teixeira F, Souza-Filho F. Apical extrusion of debris and irrigants using two hand and three engine-driven instrumentation techniques. International Endodontic Journal. 2001;34(5):354-8. (Crossref)
23. Reddy SA, Hicks ML. Apical extrusion of debris using two hand and two rotary instrumentation techniques. Journal of endodontics. 1998;24(3):180-3. (Crossref)
24. Schneider SW. A comparison of canal preparations in straight and curved root canals. Oral surgery, Oral medicine, Oral pathology. 1971;32(2):271-5. (Crossref)
25. McKendry DJ. Comparison of balanced forces, endosonic, and step-back filing instrumentation techniques: quantification of extruded apical debris. Journal of Endodontics. 1990;16(1):24-7. (Crossref)
26. Grossman LI (1950). Root Canal Therapy . 3 rd ed. Philadelphia: Lea and Febiger -.
27. Tinaz AC, Alacam T, Uzun O, Maden M, Kayaoglu G. The effect of disruption of apical constriction on periapical extrusion. Journal of endodontics. 2005;31(7):533-5. (Crossref)
28. VandeVisse JE, Brilliant JD. Effect of irrigation on the production of extruded material at the root apex during instrumentation. Journal of Endodontics. 1975;1(7):243-6. (Crossref)
29. Martin H, Cunningham WT. The effect of endosonic and hand manipulation on the amount of root canal material extruded. Oral Surgery, Oral Medicine, Oral Pathology. 1982;53(6):611-3. (Crossref)
30. Al-Omari M, Dummer P. Canal blockage and debris extrusion with eight preparation techniques. Journal of endodontics. 1995;21(3):154-8. (Crossref)
31. Fairbourn DR, McWalter GM, Montgomery S. The effect of four preparation techniques on the amount of apically extruded debris. Journal of endodontics. 1987;13(3):102-8. (Crossref)
32. Beeson T, Hartwell G, Thornton J, Gunsolley J. Comparison of debris extruded apically in straight canals: conventional filing versus profile. 04 Taper series 29. Journal of endodontics. 1998;24(1):18-22. (Crossref)
33. Vande Visse JE, Brilliant JD. Effect of irrigation on the production of extruded material at the root apex during instrumentation. J Endod. 1975;1(7):243-6. (Crossref)
34. Kandaswamy D, Venkateshbabu N. Root canal irrigants. Journal of conservative dentistry: JCD. 2010;13(4):256. (Crossref)
35. Fenoul G, Meless G, Perez F. The efficacy of R-Endo® rotary NiTi and stainless-steel hand instruments to remove gutta-percha and Resilon. International endodontic journal. 2010;43(2):135-41. (Crossref)
36. Mohorn HW, Dowson J, Blankenship JR. Odontic periapical pressure following vital pulp extirpation. Oral Surgery, Oral Medicine, Oral Pathology. 1971;31(4):536-44. (Crossref)
37. Özçopur B, Arı H, Güneş B. Kök kanal tedavisinin yenilenmesinde dört tekniğin etkinliğinin karşılaştırılması. SÜ Dişhek Fak Derg. 2009;18:122-1.
38. de Oliveira DP, Barbizam JVB, Trope M, Teixeira FB. Comparison between gutta-percha and resilon removal using two different techniques in endodontic retreatment. Journal of endodontics. 2006;32(4):362-4. (Crossref)
39. Hassanloo A, Watson P, Finer Y, Friedman S. Retreatment efficacy of the Epiphany soft resin obturation system. International Endodontic Journal. 2007;40(8):633-43. (Crossref)
40. Tanalp J, Kaptan F, Sert S, Kayahan B, Bayirl G. Quantitative evaluation of the amount of apically extruded debris using 3 different rotary instrumentation systems. Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology. 2006;101(2):250-7. (Crossref)