EFFICACY OF ONESHAPE, NEONITI A1 AND PROTAPER IN REMOVAL OF CALCIUM HYDROXIDE FROM THE ROOT CANAL SYSTEM

***Farahnaz Dadgar*[1*]*, Jaber Koohkan Siahmardi*[2]

[1]*Assistant Professor, Department of Endodontics, Oral and Dental Research Center, Zahedan University of Medical Sciences, Zahedan, Iran.*

[2]*General Dentist, Zahedan, Iran.*

****Corresponding Author:** Farahnaz Dadgar**, Email:** frhnzddgr@gmail.com*

Abstract. Background and Objectives: Remnants of calcium hydroxide (CH) used as a medicament in the root canal system can interfere with the function of sealers and compromise the success of treatment. This study aimed to compare the efficacy of One Shape, Neoniti A1 and Pro Taper rotary files in elimination of CH remnants from the root canal system.

Materials and Methods: In this vitro, experimental study, the root canals of 26 mandibular second premolars were instrumented with Pro Taper rotary system to F3. CH was applied in the canals. Twenty teeth were randomly selected for the use of three rotary file systems (rinsed and used again for all three file systems) while 6 teeth served as controls. F2 (25/.07) file of Pro Taper Universal, 25/.08 file of One Shape and 25/.08 file of Neoniti A1 were used to remove CH from the root canal system. The teeth were then longitudinally split in half. Digital images were obtained of each half and the CH remnants were scored under a stereomicroscope at x40 magnification. Data were analyzed using ANOVA, the Kruskal-Wallis test and the Mann-Whitney test. **Results:** Evaluation of the apical, middle and coronal thirds revealed a significant difference among the groups ($P<0.05$). Nepniti A1 and One Shape had similar efficacy in the coronal and apical thirds superior to that of Pro Taper. The efficacy of all three systems was the same in the middle third.

Conclusion: None of the files completely eliminated CH but Neoniti A1 and One Shape had significantly higher efficacy for this purpose.

Keywords: Calcium Hydroxide; Pro Taper; One Shape; Neoniti A1

Introduction

Elimination of intracanal microorganisms is an important goal in endodontic treatment [1]. Despite the advances in endodontic instruments and techniques, no instrument/technique can completely eliminate the bacteria from the root canal system [2]. Thus, antibacterial medicaments should be necessarily used to prevent reinfection [3]. Aside from the antibacterial property, intracanal medicaments should be biocompatible in order not to irritate the periapical tissue.

Calcium hydroxide (CH) has long been used as a preferred intracanal medicament [4]. Application of CH is recommended in infected root canals and multiple-session endodontic treatments [3]. Complete elimination of CH from the root canal system is imperative for a successful root filling [5]. CH remaining in the root canal system decreases the penetration depth of sealers into the dentinal tubules. Subsequently, the adaptation of sealers to root canal dentin decreases and microleakage occurs [6]. CH remnants decrease the bond strength of resin sealers to canal dentin [5,7,8]. They also affect the function of silicon sealers [9]. Margelos et al. [10] showed that CH impairs the standard setting of zinc oxide eugenol sealer and makes it brittle and fragile. Kim and Kim [11] demonstrated greater apical leakage in teeth with CH intracanal medicament when zinc oxide eugenol sealer was used.

CH is conventionally removed from the root canal system using master apical file along with irrigation with sodium hypochlorite and ethylenediaminetetraacetic acid (EDTA) [12]. Apical patency file and nickel titanium files can also be used for active irrigation [12-14]. However, evidence shows that this technique cannot well clean the root canal walls from CH [10,12,15]. Thus, aside from hand instruments, rotary files accompanied by irrigation are recommended for elimination of CH from the root canal system [16-19].

OneShape rotary system is suitable for fast instrumentation of the root canal system since only one file is used for root canal preparation in this system. ProTaper rotary system is also commonly used for root canal instrumentation. ProTaper files are flexible and three files are used for root canal instrumentation with this system. Neoniti A1 file has a rough surface which enhances its abrasiveness and cutting efficiency. The manufacturer claims that one Neoniti A1 file is sufficient for root canal instrumentation.

The use of rotary files especially the single-file systems is growing fast. Considering the fact that the performance of rotary files is affected by a number of factors such as their cross-sectional design, cutting efficiency and size of file tip, and the limited studies comparing the efficacy of rotary systems for CH removal, this study aimed to compare the efficacy of ProTaper, Neoniti A1 and OneShape for elimination of CH from the root canal system.

Materials and Methods

This in vitro, experimental study evaluated 26 mandibular second premolars collected from dental clinics and offices in Zahedan city. The inclusion criteria were a minimum of 15 mm of root length, no root caries or fracture, and canal curvature <15°. The exclusion criteria were root cracks or fracture prior or during the study, root canal calcification, working length<18 mm, initial file size>30, and open-apex teeth. The study was

approved in the ethics committee of Zahedan University of Medical Sciences.

Minimum sample size was calculated to be 17 teeth in each group according to a previous study [13] assuming alpha=0.05, beta=0.2 and 80% study power at 95% confidence interval. However, we included 20 samples in each group to account for the possible dropouts and increase the accuracy.

The teeth were disinfected by immersion in 5.25% sodium hypochlorite for 2 hours in order for the organic debris to dissolve. The debris and calculus were removed by a scaler, the teeth were immersed in distilled water and stored in 10% buffered formalin (DRM, Iran). The samples were inspected under a stereomicroscope (Nikon, Japan) at x40 magnification to ensure absence of cracks, fracture or caries. Periapical radiographs were obtained of the teeth in mesiodistal and buccolingual directions (Skydent, Slovak Republic) to ensure canal patency, canal curvature <15°, canal diameter smaller than F3 ProTaper Universal file (Dentsply Maillefer, Ballaigues, Switzerland) and absence of internal resorption. All steps of the procedure were performed by one operator. A #10 K-file (Dentsply Maillefer, Ballaigues, Switzerland) was used to maintain canal patency and determine the working length. It was introduced into the canal until its tip was visible at the apex; 1 mm was subtracted from this length to determine the working length. For the purpose of standardization of root length, the crowns were cut at 15 mm from the apex using a diamond disc with 0.6 mm thickness (LM, Italy). The samples were then fixed in vials containing silicon impression material (Asia Chemie Teb, Tehran, Iran). Biomechanical root canal preparation was performed using ProTaper Universal rotary file system up to F3 file along with irrigation with 5 mL of 2.5% sodium hypochlorite after using each file with a flow rate of 1 mL/s with a disposable plastic syringe and a 27-gauge needle (C-K Dental, Korea). The needle was inserted into the canal 2 mm shorter than the working length in order not to get locked in the canal. Prior to final rinsing, a #20 K-file was used to loosen the debris and dentin plugs by passing it through the apical foramen by 1 mm. A final rinse with 5 mL of 2.5% sodium hypochlorite and 5 mL of 17% EDTA (Asia Chemie Teb, Tehran, Iran) was also performed each for 1 minute. Next, the canals were rinsed with 5 mL of distilled water with a flow rate of 1 mL/s. The teeth were then removed from the silicon impression material and two longitudinal grooves were created on the external buccal and lingual surfaces of the teeth while preserving the intracanal dentin using a diamond disc under water coolant. The teeth were then longitudinally split in half using a straight elevator with prying motion. The remaining external debris were removed under the microscope. Teeth showing a dentin gap along the canal were excluded and replaced. A small amount of glue (Scotch Super Glue, 3M ESPE, St. Paul, MN, USA) was used for better adaptation and in order to prevent separation of the two halves. The teeth were then mounted again in vials containing silicon impression material. A total of 20 teeth were randomly selected for the experimental groups while 6 teeth were randomly assigned to the control groups (n=3 for the positive control and n=3 for the negative control). Samples in the negative control group did not receive any further intervention. CH paste was prepared by mixing CH powder (Golchai, Iran) and distilled water and was delivered into the canals dried with paper points using a #25 Lentulo spiral (Mani Inc., Japan). The teeth were radiographed to ensure their complete filling with CH paste. Next, 2 mm of the coronal access cavity was temporarily filled with a temporary filling material (Cavit; 3M ESPE, SeeFeld, Germany). The apex was sealed with red wax (Cavex, Holland). The teeth were incubated at 37°C and 100% relative humidity for one week. For the purpose of standardization of samples in terms of size and shape of canals, all 20 teeth were once used for assessment of the efficacy of CH removal by OneShape, and then washed and used again for Neoniti A1 and ProTaper. After using each file system and performing the assessments under the microscope, the two halves were thoroughly rinsed with distilled water and inspected under the microscope to ensure complete elimination of CH and were then used for evaluation of the efficacy of other file systems.

After removing the temporary dressing by an excavator, a #20 K-file (Dentsply Maillefer, Ballaigues, Switzerland) was used to the working length to loosen the paste and create a space for needle insertion for irrigation. The canals were then rinsed with 5 mL of 2.5% sodium hypochlorite followed by 5 mL of 17% EDTA using a syringe and 27-gauge needle each for one minute. A final rinse with 5 mL of distilled water with a flow rate of 1 mL/s was also performed. F2 (25/0.07) file of ProTaper Universal system (Dentsply Maillefer, Ballaigues, Switzerland) with a rotary hand-piece (NSK, Japan) operating at 300 rpm and 2.5 Ncm torque was used in ProTaper group. The single file (25/0.08) of the OneShape system (Micromega, France) was used in OneShape group with a hand-piece operating at 400 rpm and 3 Ncm torque while 25/0.08 Neoniti A1 file (Neolix, France) with a hand-piece operating at 400 rpm and 1.5 Ncm torque was used in the Neoniti A1 group 2 mm shorter than the working length. The entire activation period of the file was 60 seconds [20]. Irrigation with 5 mL of 2.5% sodium hypochlorite with a flow rate of 1 mL/s was also carried out every 20 seconds. Ten up-and-down and circumferential filing movements in 2 mm range were employed in use of each file. In the positive control group, the CH paste was not eliminated. The canals were then dried with paper points and the roots were removed from the impression material. The two halves were then separated. Each half was subjected to digital radiography with a digital camera (CMOS Camera, Japan) under a stereomicroscope (Nikon, Japan) at x40 magnification. The images were randomized and analyzed by Adobe Photoshop software version 16

(USA). Another observer blinded to the group allocation of samples quantified the CH particles remaining on the root canal walls by counting the pixels and reported the value as a percentage of the entire root surface area in each of the apical, middle and coronal third [16]. A scoring system proposed by Kuga et al, [13] was used for scoring as follows: score 0 indicated no CH residues, score 1 indicated small amount of CH residues remaining on the canal walls (up to 20% of the canal surface area), score 2 indicated moderate amounts of CH residues remaining on the canal walls (21% to 60% of the canal surface area) and score 3 indicated high amounts of CH residues remaining on the canal walls (over 60% of the canal surface area).

Data were analyzed using descriptive and inferential statistics. The measures of central dispersion were reported and data were analyzed using ANOVA for normally distributed data and the Kruskal-Wallis test and Mann-Whitney test for non-normally distributed data. All statistical analyses were carried out using SPSS version 22 (SPSS Inc., IL, USA).

Results

Table 1 shows the efficacy of the three file systems in removal of CH from the apical, middle and coronal thirds. The Kruskal-Wallis test showed a significant difference in CH removal from the apical, middle and coronal thirds in the One Shape group (P=0.005), Pro Taper group (P=0.008) and Neoniti A1 group (P=0.005).

Table 1. Efficacy of the three file systems in removal of CH from the apical, middle and coronal thirds (n=20)

File	Region	Mean	Std. deviation	Minimum	Maximum	P value
OneShape	Apical third	.9500	.94451	.00	3.00	0.005*
	Middle third	.6000	.88258	.00	3.00	
	Coronal third	.1500	.48936	.00	2.00	
ProTaper	Apical third	1.7500	.91047	.00	3.00	0.008*
	Middle third	.9500	.75915	.00	2.00	
	Coronal third	1.0500	.82558	.00	2.00	
Neoniti A1	Apical third	.950	.94451	.00	3.00	0.005*
	Middle third	.600	.88258	.00	3.00	
	Coronal third	.150	.48936	.00	2.00	

*Kruskal-Wallis test

Thus, pairwise comparisons were carried out between the apical, middle and coronal thirds within each group (Table 2). The Mann-Whitney test used for pairwise comparisons in One Shape group revealed significantly greater CH removal in the coronal third compared with the apical third (P=0.007). No other significant differences were noted in this group.

In the Pro Taper group, pairwise comparisons revealed that the removal of CH from the apical third was significantly lower than that in the middle (P=0.010) and coronal (P=0.027) thirds. No significant difference was noted between the coronal and middle thirds in this respect (P>0.05). In the Neoniti A1 group, pairwise comparisons revealed that the removal of CH from the coronal third was significantly higher than that in the apical (P=0.001) and middle (P=0.034) thirds. The apical and middle thirds were not significantly different in this respect (P>0.05).

Table 2. Pairwise comparisons of CH removal from the apical, middle and coronal thirds within each group

File	Group (I)	Group (J)	Mean difference (I-J)	P value	Lower bound (95% CI)	Upper bound (95% CI)

OneShape	Apical	Middle	.3500	.354	-.2573	.9573
	Apical	Coronal	.8000	.007	.1927	1.4073
	Middle	Coronal	.4500	.184	-.1573	1.0573
ProTaper	Apical	Middle	.800	.010	.1653	1.4347
	Apical	Coronal	.700	.027	.0653	1.3347
	Middle	Coronal	-.100	.924	-.7347	.5347
Neoniti A1	Apical	Middle	.350	.191	-.2573	.9573
	Apical	Coronal	.800*	.001	.1927	1.4073
	Middle	Coronal	.450	.034	-.1573	1.0573

Table 3 shows the frequency distribution of different scores of CH removal from the apical, middle and coronal thirds using the three rotary systems. The chi-square test revealed a significant difference in the percentage of CH removal from the apical, middle and coronal thirds in the One Shape (P=0.048), Pro Taper (P=0.022) and Neoniti A1 (P=0.016) groups.

Table 3. Frequency distribution of different scores of CH removal from the apical, middle and coronal thirds using the three rotary systems

File	Score		Apical third	Middle third	Coronal third	Total
Oneshape	0	Number (%)	8 (40%)	12 (60%)	18 (90%)	38 (63.3%)
	1	Number (%)	6 (30%)	5 (25%)	1 (5%)	12 (20%)
	2	Number (%)	5 (25%)	2 (10%)	1 (5%)	8 (13.3%)
	3	Number (%)	1 (5%)	1 (5%)	-	2 (3.3%)
ProTaper	0	Number (%)	3 (15%)	6 (30%)	6 (30%)	15 (25%)
	1	Number (%)	2 (10%)	9 (45%)	7 (35%)	18 (30%)
	2	Number (%)	12 (60%)	5 (25%)	7 (35%)	24 (40%)
	3	Number (%)	3 (15%)	-	-	3 (5%)
Neoniti A1	0	Number (%)	8 (40%)	10 (50%)	17 (85%)	35 (58.3%)

	1	Number (%)	5 (25%)	8 (40%)	3 (15%)	16 (26.7%)
	2	Number (%)	5 (25%)	2 (10%)	-	7 (11.7%)
	3	Number (%)	2 (10%)	-	-	2 (3.3%)

Table 4 shows the comparison of CH removal efficacy of the three files and the positive and negative control groups in the apical, middle and coronal thirds. As shown, a significant difference was noted among the three files and the positive and negative control groups regarding CH removal in the apical (P=0.000), coronal (P=0.000) and middle (P=0.000) thirds.

Table 4. Comparison of CH removal efficacy of the three files and the positive and negative control groups in the apical, middle and coronal thirds

Region	Neoniti A1	ProTaper	OneShape	Negative control	Positive control	P value*
Apical third	0.95± .94	1.75± .91	1.05±1.05	0.6± .089	3±0	.000
Middle third	.6±.88	.95± .75	.6± .68	.2 ±.44	2.8±.44	.000
Coronal third	.15± .48	1.05± .82	.15± .36	.2 ±.44	2.4± .54	.000

*Kruskal-Wallis test

Table 5 shows pairwise comparisons of the files in the apical, middle and coronal thirds. As shown, Neoniti A1 and OneShape had similar efficacy in removal of CH in all three regions (P>0.05). Neoniti A1 resulted in significantly higher removal of CH compared with Pro Taper in the apical and coronal thirds (P<0.05) but Neoniti A1 and One Shape had equal efficacy in the middle third (P>0.05). One Shape resulted in significantly higher CH removal from the apical and coronal thirds compared with Pro Taper (P<0.05) but the two files were the same in the middle third (P>0.05).

Table 5. Pairwise comparisons of the files in the apical, middle and coronal thirds

Group (I)	Group (J)	**Apical**		**Middle**		**Coronal**	
		Mean difference (I-J)	P value	Mean difference (I-J)	P value	Mean difference (I-J)	P value*
Neoniti	ProTaper	-0.8	**0.044**	-0.35	**0.576**	-0.9	**0.000**

Neoniti	OneShape	-0.1	**0.997**	0	**1.000**	0	**1.000**
Neoniti	Negative	0.35	**0.944**	0.4	**0.820**	-0.05	**1.000**
Neoniti	Positive	-2.05	**0.000**	-2.2	**0.000**	-2.25	**0.000**
ProTaper	OneShape	0.7	**0.048**	0.35	**0.576**	0.9	**0.000**
ProTaper	Negative	1.15	**0.113**	0.75	**0.272**	0.85	**0.057**
ProTaper	Positive	-1.25	**0.069**	-1.85	**0.000**	-1.35	**0.000**
OneShape	Negative	0.45	**0.871**	0.4	**0.820**	-0.05	**1.000**
OneShape	Positive	-1.95	**0.001**	-2.2	**0.000**	-2.25	**0.000**

*Mann Whitney test

Neoniti A1 and One Shape showed significantly higher efficacy than the positive control in all three regions. Pro Taper showed significantly higher efficacy than the positive control in the middle and coronal thirds ($P<0.05$) but not in the apical third ($P>0.05$). The efficacy of all three files in all three regions was the same as negative control group.

Discussion

This study aimed to compare the efficacy of OneShape, Neoniti A1 and ProTaper rotary files in elimination of CH remnants from the root canal system. The results showed that none of the rotary files successfully eliminated all CH residues from the root canal system. CH removal from the middle and apical thirds was less successful, which was in agreement with the results of previous studies [13,15-17,20-28].

Kamal et al. [18] compared the efficacy of rotary and hand files for elimination of CH from the root canal system and concluded that Rinsendo was more successful than the manual method for this purpose. Kenee et al. [16] compared ultrasonic technique, rotary system and hand instruments for removal of CH from the root canal system and found that the efficacy of rotary system and ultrasonic technique was the same for this purpose and they were both more efficient than the manual instruments. Turker et al. [19] demonstrated that self-adjusting file system and Endovac were more effective than CanalBrush and conventional irrigation syringe for elimination of CH from the apical third. We did not evaluate the manual method in our study to compare our results with those of the abovementioned studies. Faria et al. [29] found no significant difference between SAF file and ProTaper rotary system in elimination of CH from the root canal system. Difference between their results and ours may be attributed to the use of different files, duration of use of file and the fact that Faria et al. [29] used an electron microscope for their assessment. Kuga et al. [13] reported that ProTaper F1 file was more effective than K3 file in removal of CH from the cervical and apical thirds. However, their findings cannot be compared with ours due to the use of different filing systems, division of root length into cervical and apical halves and use of electron microscope for their assessment. Aliabadi [30] found no significant difference in CH removal efficacy of ProTaper and Revo-S files. Difference between their results and ours can be due to the use of different files, different activation period of files or method of root canal irrigation.

In our study, OneShape and Neoniti A1 files showed significantly higher efficacy in removal of CH from the root canal compared with the positive control. Neoniti A1 and OneShape had similar efficacy in CH removal from the coronal and apical thirds and showed superior efficacy to ProTaper rotary system. However, all three files showed similar efficacy in the middle third. ProTaper file has a triangular, convex cross-section. The Neoniti A1 file has three different rectangular cross-sections and OneShape file has a triangular cross-section in the coronal and a rhomboid cross-section in the apical region. In this study, ProTaper, OneShape and Neoniti A1 were used with a hand-piece operating at 300 rpm, 400 rpm and 400 rpm, respectively. Since the size of all three files was 25, difference in their CH removal efficacy can be attributed to the difference in their cross-sectional design, speed of rotation and distance or form of flutes. These properties affect the direction of

movement of the irrigating solution in the root canal system. The Neoniti A1 file has large flutes, which can enhance the quality of irrigation. Also, OneShape file has three different cross-sectional designs that can also affect the quality of irrigation. Difference in the amount of CH residues in the coronal and apical thirds may be due to the low speed of rotation of ProTaper file and its triangular convex cross-section. Future studies are required to assess the efficacy of other rotary files for CH removal from the root canal system with use of other root canal irrigating solutions. Also, an electron microscope can be used in future studies to more accurately assess the root canal walls and quantify the CH residues in the root canal system. Last but not least, the efficacy of rotary files with an activation time shorter or longer than 60 seconds should be evaluated for CH removal from the root canal system.

Conclusion

None of the rotary files evaluated in this study completely eliminated the CH from the root canal system but Neoniti A1 and OneShape had significantly higher efficacy for this purpose.

References

1. BYSTRÖM A, SUNDQVIST G. Bacteriologic evaluation of the efficacy of mechanical root canal instrumentation in endodontic therapy. European Journal of Oral Sciences. 1981 Aug;89(4):321-8.
2. Hülsmann M, Peters OA, Dummer PM. Mechanical preparation of root canals: shaping goals, techniques and means. Endodontic topics. 2005 Mar;10(1):30-76.
3. Siqueira Jr JF, Lopes HP. Mechanisms of antimicrobial activity of calcium hydroxide: a critical review. International endodontic journal. 1999 Sep;32(5):361-9.
4. Carrotte P. Endodontics: Part 9 Calcium hydroxide, root resorption, endo-perio lesions. British dental journal. 2004 Dec;197(12):735.
5. Barbizam JV, Trope M, Teixeira ÉC, Tanomaru-Filho M, Teixeira FB. Effect of calcium hydroxide intracanal dressing on the bond strength of a resin-based endodontic sealer. Brazilian dental journal. 2008;19(3):224-7.
6. Calt S, Serper A. Time-dependent effects of EDTA on dentin structures. Journal of endodontics. 2002 Jan 1;28(1):17-9.
7. Windley III W, Ritter A, Trope M. The effect of short-term calcium hydroxide treatment on dentin bond strengths to composite resin. Dental Traumatology. 2003 Apr;19(2):79-84.
8. Erdemir A, Ari H, Güngüneş H, Belli S. Effect of medications for root canal treatment on bonding to root canal dentin. Journal of endodontics. 2004 Feb 1;30(2):113-6.
9. Contardo L, De ML, Bevilacqua L, Breschi L, Di RL. Influence of calcium hydroxide debris on the quality of endodontic apical seal. Minerva stomatologica. 2007 Oct;56(10):509-17.
10. Margelos J, Eliades G, Verdelis C, Palaghias G. Interaction of calcium hydroxide with zinc oxide-eugenol type sealers: a potential clinical problem. Journal of Endodontics. 1997 Jan 1;23(1):43-8.
11. Kim S, Kim Y. Influence of calcium hydroxide intracanal medication on apical seal. International endodontic journal. 2002;35(7):623-8.
12. Lambrianidis T, Kosti E, Boutsioukis C, Mazinis M. Removal efficacy of various calcium hydroxide/chlorhexidine medicaments from the root canal. International Endodontic Journal. 2006 Jan;39(1):55-61.
13. Kuga MC, Tanomaru-Filho M, Faria G, Só MV, Galletti T, Bavello JR. Calcium hydroxide intracanal dressing removal with different rotary instruments and irrigating solutions: a scanning electron microscopy study. Brazilian dental journal. 2010;21(4):310-4.
14. Plotino G, Pameijer CH, Grande NM, Somma F. Ultrasonics in endodontics: a review of the literature. Journal of endodontics. 2007 Feb 1;33(2):81-95.
15. Lambrianidis T, Margelos J, Beltes P. Removal efficiency of calcium hydroxide dressing from the root canal. Journal of Endodontics. 1999 Feb 1;25(2):85-8.
16. Kenee DM, Allemang JD, Johnson JD, Hellstein J, Nichol BK. A quantitative assessment of efficacy of various calcium hydroxide removal techniques. Journal of endodontics. 2006 Jun 1;32(6):563-5.
17. Balvedi RP, Versiani MA, Manna FF, Biffi JC. A comparison of two techniques for the removal of calcium hydroxide from root canals. International endodontic journal. 2010 Sep;43(9):763-8.
18. Kamal A, Behnaz G, Marjan H, Ali MA, Sharare MZ. Compare the effectiveness of manual technique and rinsendo system in the irrigation of Ca (OH) 2 from root canals. Res J Med Sci. 2013;7:9-12.
19. Türker SA, Koçak MM, Koçak S, Sağlam BC. Comparison of calcium hydroxide removal by self-adjusting file, EndoVac, and CanalBrush agitation techniques: an in vitro study. Journal of conservative dentistry: JCD. 2013 Sep;16(5):439.
20. Khaleel HY, Al-Ashaw AJ, Yang Y, Pang AH, Ma JZ. Quantitative comparison of calcium

hydroxide removal by EndoActivator, ultrasonic and ProTaper file agitation techniques: an in vitro study. Journal of Huazhong University of Science and Technology [Medical Sciences]. 2013 Feb 1;33(1):142-5.
21. Rödig T, Hirschleb M, Zapf A, Hülsmann M. Comparison of ultrasonic irrigation and RinsEndo for the removal of calcium hydroxide and Ledermix paste from root canals. International endodontic journal. 2011 Dec;44(12):1155-61.
22. Van der Sluis LW, Wu MK, Wesselink PR. The evaluation of removal of calcium hydroxide paste from an artificial standardized groove in the apical root canal using different irrigation methodologies. International Endodontic Journal. 2007 Jan;40(1):52-7.
23. Rödig T, Vogel S, Zapf A, Hülsmann M. Efficacy of different irrigants in the removal of calcium hydroxide from root canals. International endodontic journal. 2010 Jun;43(6):519-27.
24. Kuga MC, Campos EA, Faria-Junior NB, Só MV, Shinohara AL. Efficacy of NiTi rotary instruments in removing calcium hydroxide dressing residues from root canal walls. Brazilian oral research. 2012 Feb;26(1):19-23.
25. Taşdemir T, Celik D, Er K, Yildirim T, Ceyhanli KT, Yeşilyurt C. Efficacy of several techniques for the removal of calcium hydroxide medicament from root canals. International endodontic journal. 2011 Jun;44(6):505-9.
26. de Melo Ribeiro MV, Silva-Sousa YT, Versiani MA, Lamira A, Steier L, Pécora JD, de Sousa-Neto MD. Comparison of the cleaning efficacy of self-adjusting file and rotary systems in the apical third of oval-shaped canals. Journal of Endodontics. 2013 Mar 1;39(3):398-401.
27. Maalouf L, Zogheib C, Naaman A. Removal efficiency of calcium hydroxide dressing from the root canal without chemically active adjuvant. The journal of contemporary dental practice. 2013 Mar 1;14(2):188.
28. Faria G, Viola KS, Kuga MC, Garcia AJ, Daher VB, De Pasquali Leonardo MF, Tanomaru-Filho M. Effect of rotary instrument associated with different irrigation techniques on removing calcium hydroxide dressing. Microscopy research and technique. 2014 Aug;77(8):642-6.
29. Faria G, Kuga MC, Ruy AC, Aranda-Garcia AJ, Bonetti-Filho I, Guerreiro-Tanomaru JM, Leonardo RT. The efficacy of the self-adjusting file and ProTaper for removal of calcium hydroxide from root canals. Journal of Applied Oral Science. 2013 Aug;21(4):346-50.
30. Tahere Aliabadi F. Comparison of Revco-S and Prosper rotary files to remove calcium hydroxide from root canal. 2015