

Original Article

Comparison of the efficacy of various files and irrigations on calcium hydroxide removal: An *in vitro* study

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ABSTRACT

Background: This study aimed to assess how effective hand K-files and XP-Endo Finisher rotary files, combined with two different irrigation solutions (chlorhexidine [CHX] and sodium hypochlorite), are in eliminating calcium hydroxide (CH) from the walls of root canals.

Materials and Methods: Eighty-two single-root canal teeth were included in this *in vitro* study. After decoronation, the root canals were prepared with master apical file #30, and to shape the coronal part, #1–3 Gates-Glidden drills were used. The specimens were divided into four experimental groups ($n = 18$) and two control groups ($n = 5$). In all groups except the negative control group, CH was applied to the root canal system, and the access cavity was temporarily restored with zinc oxide eugenol. The samples were incubated for 1 week at a temperature of 37°C and a humidity level of 100%. For CH removal, the experimental groups received different irrigation regimens and file types: group 1: hand K-file + 5.25% sodium hypochlorite, group 2: XP-Endo Finisher rotary file + 5.25% sodium hypochlorite, group 3: hand K-file + 0.12% CHX, and group 4: XP-Endo Finisher rotary file + 0.12% CHX. CH was not removed from the positive control group. The root canals were then longitudinally sectioned, and the remaining CH in the apical, middle, and coronal thirds was quantified using a stereomicroscope. Statistical analysis was performed using one-way and two-way ANOVA and the Kruskal–Wallis test ($P < 0.05$).

Results: The XP-Endo Finisher rotary file and CHX irrigation resulted in significantly higher residual CH in the apical third ($P < 0.05$). Conversely, the lowest mean residual CH was observed in the coronal third with hand K-file and sodium hypochlorite irrigation ($P < 0.05$). Sodium hypochlorite exhibited superior effectiveness in CH removal compared to CHX ($P < 0.05$).

Conclusion: There was no discernible advantage of using XP-Endo Finisher over hand K-file for the removal of CH. However, sodium hypochlorite proved to be more effective than CHX in achieving CH removal.

Key Words: Calcium Hydroxide, root canal irrigants, root canal medicaments, root canal therapy

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INTRODUCTION

The microbial count in infected dental root canals is reduced through the combined process of root canal instrumentation, irrigation, and the application of intracanal medications.^[1-3] Studies indicate that chlorhexidine (CHX) exhibits antimicrobial properties comparable to sodium hypochlorite, and it is commonly recommended to use both substances simultaneously and periodically for enhanced irrigation and disinfection of root canals.^[4] Despite these efforts, the complete elimination of microorganisms from the root canal system is not feasible, necessitating the use of intracanal medicaments with antibacterial properties during intervals between treatment sessions.^[1]

Due to its excellent antibacterial properties, calcium hydroxide (CH) is widely employed as the preferred intracanal medicament.^[1,5,6] It enhances the effectiveness of sodium hypochlorite in dissolving tissue within the root canal system. Typically, CH paste is prepared by combining CH powder with water or saline and is left in the root canal system for a duration of several days to weeks, depending on the specific case.^[7]

However, the incomplete removal of CH from the root canal system can have negative implications for the treatment outcome. Residual CH can lead to inconsistent thickness of the sealer throughout the root canal system due to its gradual degradation, potentially affecting the flow of the sealer and hindering optimal penetration into the dentinal tubules.^[8-11] Additionally, the interaction between CH and zinc oxide eugenol sealers can make the sealer brittle and granular.^[5,12] Therefore, it is crucial to ensure the complete elimination of CH from the root canal system before the final obturation of the dental root canal.^[13]

To eliminate CH from the root canal system, various methods can be employed. These include manual files, rotary nickel–titanium (NiTi) files, patency files, as well as instruments for activating irrigating solutions such as sonic and ultrasonic instruments.^[14-18] Plotino *et al.*^[19] also highlighted the advantages of incorporating passive ultrasonic instruments in combination with the irrigating solution for the effective removal of CH from the root canal system.^[19]

The use of hand files for CH removal from the root canal system may result in residual deposits in difficult-to-reach areas.^[16,20] Furthermore, drawbacks

associated with hand files include increased preparation time and the potential for non-uniform preparation.^[21]

NiTi rotary files have been proposed as a viable alternative to hand files, offering several advantages. These advantages encompass faster preparation time, more consistent canal preparation, and a reduced likelihood of procedural errors.^[14,15,22-24]

Single-file rotary systems are frequently favored over multi-file systems due to their time and cost-saving advantages.^[25] One such system is the XP-Endo Finisher, made by FKG Dentaire in Switzerland, which is a highly flexible rotary file utilizing the shape-memory properties of NiTi alloy. It helps preserve dentin, reaches difficult areas inaccessible to traditional tools, efficiently removes medication and residual materials during retreatment,^[26] and possesses a suitable design for removing both pulpal and root filling residues from the root canal system. As a result, it holds promise for the effective removal of CH as well.^[27,28]

The objective of this study was to evaluate the effectiveness of hand K-file and XP-Endo Finisher rotary file, in combination with irrigation using CHX and sodium hypochlorite, in removing CH as an intracanal medicament from the dental root canals.

MATERIALS AND METHODS

For this *in vitro* study, a total of 82 extracted human single-root canal teeth with round cross-sectional diameters were conveniently selected. The teeth chosen met the following criteria: mature apices, a round root canal diameter matching a #20 file size, absence of cracks, fractures, caries, previous restorations, and any curvature.

With a desired study power of 80%, the sample size for each group was calculated to be $n = 16$. To account for a potential 10% dropout rate, a total of $n = 18$ teeth were included in each group. The selected teeth were immersed in 3% sodium hypochlorite solution for 48 h, followed by cleaning of the root surfaces and storage in saline. Radiographs were taken using a Kavo radiography system (Santa Catarina, Brazil) to confirm the presence of a single-root canal and determine the mesiodistal and buccolingual position of the apical foramen.

The tooth crowns were separated from the roots at the cemento-enamel junction using a diamond disc, and

the lengths of the roots were standardized. The final working length was determined to be 1 mm shorter than the apical foramen. Root canals were then prepared with a hand K-file #30 as a master apical file (Mani, Japan) and coronally shaped further with #1–3 Gates-Glidden drills (Mani, Japan). Throughout the preparation process, the root canals were rinsed with 2 mL of 2.5% sodium hypochlorite after each file usage and, after that, were dried with paper points. Subsequently, the samples were randomly divided into four groups, with each group consisting of $n = 18$ teeth. In all groups except the negative control group, CH (Metapaste, META BIOMED Co, Ltd, Chungbuk, South Korea) was applied into the root canal system up to the working length using a Lentulo spiral (Medin, Czech Republic) rotating at 30,000 rpm, and left in place for 1 week. The access cavity was temporarily restored with zinc oxide eugenol (Golchai, Iran) at a thickness of 3 mm, and the apex was sealed with sticky wax. The samples were then incubated for 1 week at a temperature of 37°C and a humidity level of 100%.

Following the incubation period, the removal of CH at working length from the root canals of specimens in group 1 was performed using a #30 hand K-file, accompanied by root canal irrigation using 2cc of 5.25% sodium hypochlorite (Golrang, Iran) within 20 s; in group 2 using XP-Endo Finisher rotary file (FKG, Switzerland) operating at 800 rpm and 1 Ncm torque accompanied by 2cc of 5.25% sodium hypochlorite irrigation in 20 s; in group 3 using #30 hand K-file accompanied by root canal irrigation with 2cc of 0.12% CHX (Iran Najo Pharmaceutical Co., Tehran, Iran); and in group 4 using XP-Endo Finisher operating at 800 rpm and 1Ncm torque accompanied by 2cc of 0.12% CHX irrigation. In all experimental groups, the root canals were dried with absorbent paper points, and then the teeth were longitudinally sectioned into mesial and distal halves by a cutting machine (CNC, Nemophanavar Pars, Iran). Furthermore, samples were inspected under a stereomicroscope (SMP 200, HP, CA, USA) at $\times 30$ magnification, and the amount of residual CH was inspected in the coronal, middle, and apical thirds of the root canals. Specific areas containing CH were selected, and both the area of these CH-containing regions and the entire root canal were measured. Ultimately, we compared this ratio to the percentages found in various other root canals. Also, five teeth served as the positive control group and underwent root canal preparation and CH

placement without performing any irrigation protocol. Specimens of the negative control group ($n = 5$) underwent root canal preparation without placement of CH intra-canal medication.

Statistical analysis was conducted using SPSS version 24. The Kruskal–Wallis test, along with a *post hoc* test with Bonferroni adjustment and one-way and two-way ANOVA, were performed at a significance level of 0.05.

The study protocol was approved by the ethics committee and institutional review board of the university (IR.IAU.KHUISF.REC.1398.114).

RESULTS

The lowest mean of the residual CH was noted in the coronal third of the root canal in the hand K-file + sodium hypochlorite group. The highest mean of the residual CH was noted in the apical third of the root canal in the XP-Endo Finisher + CHX group [Table 1].

The Kruskal–Wallis test, followed by the *post hoc* test with Bonferroni adjustment, showed significant differences between the hand K-file + sodium hypochlorite and hand K-file + CHX groups ($P = 0.002$) and also between hand K-file + sodium hypochlorite and XP-Endo Finisher + CHX groups ($P < 0.001$). No other significant differences were noted ($P > 0.05$).

The data regarding the residual CH in the coronal third of the root canal was not normally distributed according to the Kolmogorov–Smirnov test. The interaction effect of the type of irrigating solution and the type of file on the residual CH was significant ($P = 0.048$). In addition, Levene's test revealed that the assumption of homogeneity of variances was not met. Thus, the data were analyzed using the Kruskal–Wallis test, which revealed a significant difference in the residual amount of CH in the coronal third of the root canals among the groups ($P = 0.004$). Pairwise comparisons followed by Bonferroni adjustment revealed significant differences between the hand K-file + sodium hypochlorite and XP-Endo Finisher + sodium hypochlorite groups ($P = 0.034$), hand K-file + sodium hypochlorite and hand K-file + CHX groups ($P = 0.015$), and hand K-file + sodium hypochlorite and XP-Endo Finisher + CHX groups ($P = 0.014$). No other significant differences were noted ($P > 0.05$).

Table 1: The amount of residual calcium hydroxide in the dental root canal walls after using two different files and irrigation solutions

File type	Irrigating solution	Residual calcium hydroxide in the coronal third (mm ²)	Residual calcium hydroxide in the middle third (mm ²)	Residual calcium hydroxide in the apical third (mm ²)
K-file	Sodium hypochlorite			
	Mean	0.136	0.182	0.173
	SD	0.179	0.140	0.179
	Minimum	0.001	0.028	0.004
	Maximum	0.780	0.480	0.702
	Chlorhexidine			
	Mean	0.377	0.414	0.399
	SD	0.288	0.275	0.279
XP-Endo finisher	Minimum	0.016	0.010	0.010
	Maximum	0.843	0.871	0.750
	Sodium hypochlorite			
	Mean	0.313	0.306	0.280
	SD	0.178	0.182	0.127
	Minimum	0.011	0.003	0.012
	Maximum	0.660	0.640	0.550
	Chlorhexidine			
	Mean	0.344	0.377	0.485
	SD	0.219	0.210	0.208
	Minimum	0.060	0.111	0.130
	Maximum	0.710	0.830	0.790

SD: Standard deviation

Considering the normality of data and homogeneity of variances, two-way ANOVA was applied, which showed the significant effect of the type of irrigating solution on the residual CH in the middle third ($P = 0.003$). The effect of the type of file ($P = 0.380$) and the interaction effect of the type of file and the type of irrigating solution ($P = 0.104$) on residual CH were not significant. Then, one-way ANOVA was applied to compare the four groups, which revealed significant differences between the hand K-file + sodium hypochlorite and hand K-file + CHX ($P = 0.007$) and also hand K-file + sodium hypochlorite and XP-Endo Finisher + CHX ($P = 0.032$) groups. No other significant differences were noted ($P > 0.05$).

Since data were not normally distributed and the homogeneity of variances was not met in the apical third, the Kruskal–Wallis test was applied, followed by a *post hoc* test with Bonferroni adjustment. The results showed significant differences between the hand K-file + sodium hypochlorite and hand K-file + CHX ($P = 0.021$), and also hand K-file + sodium hypochlorite and XP-Endo Finisher file + CHX ($P < 0.001$) groups. No other significant differences were noted ($P > 0.05$).

DISCUSSION

This study assessed the amount of residual CH in the root canal system after using a hand K-file and XP-Endo Finisher rotary file along with two different irrigations of CHX and sodium hypochlorite.

For standardization and to minimize the effect of canal shape as a confounding factor on the results, single-canal teeth with round root cross-sections were selected in this study. Moreover, as a notable strength of our study, the root length was also standardized by decoronation of teeth, and all procedures were conducted by the same examiner.

According to the results of our study, the hand K-file was slightly, but not significantly, more effective than XP-Endo Finisher for the removal of CH from the root canal system, which can be due to the lower cutting efficiency of NiTi rotary files compared to the stainless-steel hand K-files.

Our findings are partly inconsistent with the results of studies done by Denna *et al.*^[26] and Kfir *et al.*^[29] They presented the XP-Endo Finisher as a better removing method for apical third, which may be due to more contact time by running it for a longer time or using it for several cycles. Different results compared to

our study could also be due to the different irrigation protocols as well as different methods of inspection for residual CH. Their inability to completely remove the CH from the root canal is in accordance with the result of our study.^[26,29]

In another study, Ahirwar *et al.*^[30] concluded that EndoVac was significantly more effective than rotary files in removing CH in the coronal and apical thirds. Böttcher *et al.*^[31] also reported no significant difference between the efficacy of ultrasonic and manual techniques in removing CH. These inconsistent findings are also represented in a systematic review regarding the supplementary effect of irrigant activation.^[32] However, due to the various applied methodologies, including file types and root canal anatomies with different filling materials, results are not comparable to the results of our study. Nevertheless, they all concluded alike that none of the reported regimens could be able to remove CH completely from the root canal system, which is in accordance with our findings.^[33-40]

According to the results of this study, root canals irrigated with sodium hypochlorite, irrespective of the type of used file, showed lower residual CH, which can be due to the higher solubilizing property of sodium hypochlorite compared to the CHX. In addition, the elimination of CH was greater in the coronal third in comparison with the middle and apical thirds of the dental root canals, which could be due to the easier flow of the irrigating solutions in the coronal area. The study conducted by Harzivartyan *et al.*^[37] investigated the effectiveness of NaOCl and dual rinse HEDP with various irrigation systems for CH removal, and they did not observe any significant differences. However, it is important to note that their study used different irrigation solutions, making it difficult to directly compare their findings with our study.

Regarding the inspection method of residual CH, Chawla and Kumar^[41] used a scanning electron microscope to compare the efficacy of different methods and irrigating solutions for CH removal from the root canal system. They found no significant difference between the groups and reported that none of the methods could completely eliminate CH from the root canal system. Despite different methodologies, their results agreed with our findings.

Due to the various methodologies in recent studies, comparing results and discussing them in more detail was not possible. To overcome this limitation of our

study, further studies with standardized methodology are highly recommended.

CONCLUSION

Within the limitations of this study, it can be concluded that hand the K-file was slightly, but not significantly, superior to the XP-Endo Finisher for the removal of CH from the root canal system. However, sodium hypochlorite was significantly superior to CHX for this purpose. However, none of these methods were able to completely eliminate CH from the root canal system.

For future studies, it is recommended to use more advanced techniques such as micro-computed tomography and electron microscopy to quantify the residual CH in the root canal system. Also, the efficacy of other rotary file types for this purpose, considering the duration, cycle, and amount of instrumentation, should be investigated in future studies. Coloring agents could also be added to CH for easier detection of residual CH in the root canal system.

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Conflicts of interest

The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial or non-financial in this article.

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