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Removal of calcium hydroxide from artificial grooves in straight root canals using ultrasonic irrigation, navitip FX and endovac

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Abstract

Aim: The aim of this study was to compare the efficacy of conventional syringe, passive ultrasonic irrigation (PUI), Navitip FX and EndoVac irrigation system in removing calcium hydroxide from standardized artificial grooves in straight root canals.

Method: The root canals of 68 human mandibular premolars with straight root canals were prepared using Protaper Universal Rotary files (Dentsply Malleifer) up to size F4, and the teeth were split longitudinally. A lateral groove in the apical was prepared in each root half and filled with calcium hydroxide, and the root halves were reassembled. Four experimental groups of 15 samples each were established according to the removal techniques: group A; side vented needle; group B, EndoVac; group C, Navitip FX; group D, PUI. One positive control group and one negative control group of 4 samples each were also included in the study. The activation procedures were performed for 1 minute each with 10 mL 3 % sodium hypochlorite and 10 mL 17% EDTA as the irrigants. The cleanliness of the grooves was scored under 20 X magnification using a stereomicroscope. The median of scoring was analyzed using the Kruskal-Wallis test (P = .05).

Results: PUI (median = 1) was significantly more effective in the removal of calcium hydroxide than the Navitip FX (median = 2), EndoVac (median=3) and conventional needle (median=3). There were no significant differences among Navitip, EndoVac and needle groups.

Conclusion: the use of PUI system with the combination of EDTA and NaOCl enhanced Ca $(OH)_2$ removal from apical third of root canals.

Keywords: calcium hydroxide, PUI, EndoVac, Navitip FX

Introduction

Calcium hydroxide, Ca $(OH)_2$ is a commonly used intracanal medicament because of its proven antimicrobial activity [1], for its capacity to neutralize bacterial endotoxin [2] and stimulate apical and periapical repair [3]. Research has shown that remnant Ca (OH) 2 on dentin walls can affect the penetration of sealers into the dentinal tubules and increase apical leakage [4]. Remnants can also hinder the bond of sealers to the root canal dentin [5]. Therefore, complete removal of Ca $(OH)_2$ placed inside the root canal before obturation of the root canal system is recommended. The most frequently described method for removing $Ca(OH)_2$ is instrumentation of the root canal with a master apical file at the working length and copious irrigation of sodium hypochlorite (NaOCl) and ethylene di-amine tetra acetic acid (EDTA) [6]. Previous studies have investigated the efficacy of Ca $(OH)_2$ removal with different devices and irrigation systems [7, 8].

Passive ultrasonic irrigation (PUI) uses an ultrasonically activated instrument inside the irrigant filled root canal. The mechanical agitation provided by ultrasonic instrumentation in conjuction with irrigation may also ehance removal of caoh [9]. The EndoVac system (Discus Dental, Culver City, CA) is an apical negative pressure (ANP) irrigation device designed to deliver irrigating solutions to the apical portion of the canal system and to suction out debris [10]. ANP irrigation at a sufficient volume and flow removes the smear layers and displaces debris. Recently a 30-gauge irrigation needle covered with a brush (NaviTip FX, Ultradent, South Jordan, UT) was introduced into the market for effective removal of smear layer from root canals. In a study, Navitip FX showed promising results in terms of smear layer removal [11]. The aim of our study is to compare the efficacy of different mechanical agitation methods to remove calcium hydroxide medicament from an artificial standardized groove in the apical third of root canals.

Materials and Methods

Sixty eight mandibular single-rooted premolars were selected, and the crowns of the teeth were removed at 12 mm from the apex to standardize the length of the roots. The root canals were shaped with ProTaper rotary files (Dentsply Maillefer, Ballagiues, Switzerland) up to an F4 (# 40) master apical file size. During the preparation, the root canal was irrigated with 2 mL 3% sodium hypochlorite (NaOCl) solution (Parcan, Septodont, India) after each instrument. After instrumentation, a final flush was applied using 5 mL 17% EDTA (Prevest Denpro, India) for 1 minute and 5 mL 2.5% NaOCl for 1 minute. The root canals were then dried with paper points. All the roots were grooved longitudinally on the buccal and lingual surfaces with a diamond disk under copious water irrigation, avoiding penetration into the root canal. The roots were then split into 2 halves with a small chisel. A 15 K-file (SybronEndo, USA) was reduced to a width of 0.2 mm and attached to the handpiece of the Satalec P5 Newtron ultrasonic system (Satelec, Merignac, France)) using the provided chuck mechanism. A longitudinal groove of 3 mm in length, 0.2 mm in width, and 0.5 mm in depth was then cut in the root canal dentine of one half of each tooth at a distance of 2–5 mm from the apex to simulate the uninstrumented canal extensions in the apical half (Fig. 1). A toothbrush was used to remove debris from the root halves and grooves. The grooves were filled with an aqueous calcium hydroxide suspension, and photographs were taken at 10X magnification. The root halves were reassembled and fixed with wax. The apical foramen was covered with wax in order to simulate a closed system, and t The specimens were fixed in test tubes filled with silicone (Affinis, Coltene, Switzerland).he roots were embedded into plastic tubes with silicone (Silaplast).. Calcium hydroxide paste (ApexCal; Ivoclar Vivadent, Switzerland) was placed into each canal using an ISO size 25 paste carrier (Mani Inc.; Japan). The access cavities were temporarily sealed with a cotton pellet and Cavit (3M ESPE, Germany). The specimens were then kept at 37˚ C with 100% humidity for 1 week. The specimens were randomly allocated into 4 experimental groups (n = 15), one positive (n = 4) and one negative (n = 4) control groups depending upon the irrigation method.

Group A (Conventional needle irrigation)
The root canals received a final flush of 10 mL 17% EDTA followed by 10 mL 3% NaOCl using a 30 gauge side vented needle 1mm short of working length.

Group B (EndoVac): the canals were first irrigated for 1 minute with 5 mL 17 % EDTA using the macrocannulas. The microcannulus was then inserted to the full WL, and the canals were irrigated with 5 mL 17% EDTA for 30 seconds and followed by 30 seconds of soaking [12]. This was followed by irrigation with 3% NAOCl using the same protocol.

Group C (Navitip FX): A size 30 NaviTip FX was placed 1 mm short of working length, and intracanal push and pull strokes were performed along the canal wall (each with 6 mm amplitude reaching 1 mm short of working length) with concomitant delivery of irrigants, first with 10 mL 17 % EDTA then with 10 mL 3% NaOCl for 1 minute.

Group D (Passive Ultrasonic Irrigation): In this group passive ultrasonic irrigation was performed, using a size 15 K-file attached to an ultrasonic handpiece (Satelec, Merignac, France) through a chuck mechanism. The canal was filled with EDTA, and the ultrasonic file was placed into the canal 1 mm short of working length without touching the walls, so that it could vibrate freely. The ultrasonic file was activated at a power setting of 4 for 1 minute. File was activated only for intervals of 12 seconds. Between each interval, the canals were refilled with 2 ml irrigant by placing the 30-gauge needle into the canal 1 mm short of working length. This procedure was repeated 5 times, so that total duration of ultrasonic irrigation was 1 minute and total volume of irrigant is 10 ml. This was followed by irrigation with 3% NAOCl using the same protocol.

The Ca $(OH)_2$ medicament material was not applied to the negative control. It was applied to the positive control but not subsequently removed. The root canals were dried with paper points, and the roots were disassembled to evaluate the removal of the Ca $(OH)_2$ medicament. The amount of remaining CH in the grooves was evaluated under a stereomicroscope (Kyowa Getner, Japan) under 20 X by two calibrated endodontists using a numeric evaluation scale described by Van der Sluis *et al.* [13]. The scoring system was as follows: score 0, the groove is entirely empty; score 1, $Ca(OH)_2$ is present in less than 50% of the groove; score 2, $Ca(OH)_2$ is present in more than 50% of the groove, but not completely; and score 3, the groove is completely covered with $Ca(OH)_2$. Evaluation was conducted based on the color codes by two endodontists blinded to the group number. Before scoring, the two endodontists assessed 50 randomly selected specimens simultaneously for calibration purposes. In the case of discrepant scores, a consensus was reached by discussion. The scoring results were expressed as medians and analyzed using the Kruskal-Wallis test. The level of significance was set, P = .05. The Cohen kappa value was calculated for interexaminer agreement.

Results
The positive controls showed a score of 3, and the negative controls showed a score of 0. Post hoc analysis revealed that PUI was significantly more effective in the removal of calcium hydroxide than the Navitip Fx, EndoVac and conventional needle (Table 1). There were no significant differences among Navitip, EndoVac and needle groups (P>0.05).

Table 1: Scoring results of experimental groups

Scores	0	1	2	3	Median (IQR)	p value
Group A (Needle)	0	1	2	12	2 (2-3)[a]	<0.01*
Group B (Endovac)	0	2	1	12	2 (2-3)[a]	
Group C (Navitip)	1	2	5	7	3 (2-3)[a]	
Group D (PUI)	2	7	6	0	1 (1-2)[b]	
Kruskal-Wallis statistical analysis	p value					
Group A vs B	0.81					
Group A vs C	0.19					
Group A vs D	<0.01*					
Group B vs C	0.07					
Group B vs D	0.004*					
Group C vs D	0.02*					

PUI: passive ultrasonic irrigation, Values with different superscript letters were statistically different at P<0.05 (Kruskal-Wallis test), *: statistically significant

Discussion
Intracanal medicaments such as calcium hydroxide should be completely removed from the root canal before obturation because remnants negatively affect the quality of the obturation.[14] The aim of this study was to compare four different methods of irrigant activation (passive ultrasonic irrigation, apical negative pressure system, Navitip Fx, needle irrigation) for the removal of calcium hydroxide from artificial grooves in straight root canals. In our study, complete removal of calcium hydroxide from the root canal was not achieved with any of the methods. This is a consistent finding in some past studies too [6, 13, 15]. In our study, we used an artificial standardized groove design in evaluation of Ca (OH) 2 medicament removal. Many studies in the past had followed the same procedure [8, 13, 16]. The groove model makes it possible to standardize the size and the location of the grooves and the amounts of medicament used before irrigation. A drawback of this artificial standardized groove design is that it does not represent the complexity of a natural root canal system.

In the literature, calculation of the residual amount of used an artificial standardized groove design in evaluations of Ca $(OH)_2$ medicament removal remaining in the root canal were made by calculating the area of the remnant on dentin wall, SEM analysis, volume analysis with spiral CT, and by using a micro-CT. We preferred the scoring method described in the study by van der Sluis, *et al*. [13] because it is a simple and easily accessible technique and used in many previous studies [17, 18]. The results of the present study showed that PUI was more effective than EndoVac and conventional syringe irrigation in removing the Ca $(OH)_2$ medicament from an artificial standardized groove in the apical part of the root canal. Similar to these findings, several previous studies showed that Ca $(OH)_2$ medicament removal was superior with PUI compared with conventional syringe irrigation [7, 13, 19, 20]. PUI technique is based on the transmission of acoustic energy to an irrigation solution [21]. The acoustic transmission increases the penetration of irrigant to the irregular canal areas and subsequently, CH removal capacity of the irrigant increases too. The efficiency of PUI is also improved with fresh irrigant replacement [22].

The present study revealed that there was no significant difference between syringe irrigation and EndoVac. The suspended medicament particles might have blocked the holes of microcannula and diminished its sucking effect and resulted in insufficient Ca $(OH)_2$ removal. Blockage of the holes of the micro cannula has been a matter of concern [23]. In contrast to our findings, Y€ucel *et al*. [20] reported that the EndoVac system is superior to conventional irrigation needles in removing Ca $(OH)_2$ medicament. They placed the medicament into the root canal for SEM analysis and did not make the standardized groove. The different experimental design might explain the conflicting results. Although CanalBrush removed more Ca $(OH)_2$ than the needle group, this difference was not statistically significant. This might be due to diminished action of brush as well as the irrigant itself at the apical third of root canal.

Conclusion

Within the limitations of this study, the use of PUI system with the combination of EDTA and NaOCl enhanced Ca (OH) 2 removal. PUI was more effective in removing Ca (OH) 2 from the lateral grooves in the apical parts of the root canal than the EndoVac and conventional syringe irrigation systems.

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