ORIGINAL RESEARCH PAPER

Dentistry

COMPARATIVE EVALUATION OF EFFICACY OF TWO DIFFERENT TECHNIQUES IN REMOVING INTRACANAL MEDICAMENT (CALCIUM HYDROXIDE) FROM THE ROOT CANAL SYSTEM: AN IN VITRO SCANNING ELECTRON MICROSCOPE STUDY

KEY WORDS: Calcium hydroxide, ProUltra

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ABSTRACT

Introduction: The purpose of this study was to evaluate the efficacy of two different techniques in removing Calcium Hydroxide ($Ca[OH]_2$) from the root canal by using a scanning electron microscope. **Methods:** Thirty extracted single-rooted teeth were divided randomly into 2 groups. Canal instrumentation was done, and the teeth were filled with $Ca(OH)_2$ paste. One week later, 2 techniques were used for $Ca(OH)_2$ removal. In the first group, the canals were cleaned with a master apical file. The second group was irrigated using the and ProUltra (Dentsply Tulsa, Tulsa,OK) system (Ultrasonic irrigation device). Both the groups were irrigated with 3 mL (18%) EDTA and 2 mL (1%) NaOCl for 1 minute. The canal walls were viewed, and the remaining amount of $Ca(OH)_2$ was evaluated using a scanning electron microscope. A scoring system was used to assess the amount of residue $Ca(OH)_2$ on each third of the canal. The obtained data for comparisons between the master apical file and Ultrasonic irrigation device were statistically analyzed. **Results:** To compare the 2 devices, the results were statistically analyzed. **Conclusions:** None of the two investigated techniques removed the $Ca(OH)_2$ dressing completely. However, the Ultrasonic irrigation System showed better results in removing $Ca(OH)_2$ in each third of the root canals in comparison with the MAF technique.

INTRODUCTION

The reduction or elimination of microorganisms is considered one of the main goals of endodontic therapy (1). However, among the available instrumentation techniques, none achieve a completely cleaned root canal system (2). Therefore, the use of intra canal medicaments has been advocated in order to enhance the disinfection process (3-5). The most commonly used intra canal medicament is Calcium Hydroxide (Ca(OH)2) because of its various biological properties such as antibacterial efficacy against the majority of endodontic pathogens (6), high alkalinity, inhibition of tooth resorption, biocompatibility (7) and tissue dissolving ability.

However, the calcium hydroxide medicament has to be removed before the root filling (8). Residual calcium hydroxide on the root canal walls may increase apical leakage of gutta- percha root fillings when a zinc oxide-eugenol sealer is used (9). In addition, such a remnant changes the physical properties of some sealers, reducing the flow and setting time (10) and preventing the penetration of sealers into dentinal tubules (11).

Mechanical instrumentation with a master apical file (MAF) and copious irrigation with sodium hypochlorite (NaOCl) and EDTA are the most frequently described methods for the removal of calcium hydroxide from the root canal (12,13). However, using different devices (Sonic/Ultrasonic) for the activation of an intracanal solution have been proposed to improve the mechanical flushing action of the irrigant (14).

The Pro Ultra Piezo Flow ultrasonic irrigation needle has been shown to be an effective tool for improved root canal irrigation (15). An ultrasonic unit is used in conjunction with these needles to provide the energy for tip oscillation. Continuous ultrasonic irrigation facilitates the introduction of irrigants into the root canal system, removes debris from isthmuses, provides better debridement of the root canal and promotes the disruption of biofilms.

AIM AND OBJECTIVE(S):

Aim is to evaluate the efficacy of two different techniques (Master apical file and ultrasonic irrigation) of removal of intra canal medicament (water based Calcium Hydroxide) from the coronal, middle and apical portions of root canal systems in combination with sodium hypochlorite and EDTA under scanning electron microscope.

METHODS OF SAMPLE SELECTION:

After getting approved by Institutional Ethical committee/ Institutional Review board, the study was conducted on 30 mandibular premolars extracted for orthodontic or periodontal purposes. Inclusion criteria includes non-carious, single-rooted, teeth with fully formed apices, absence of calcifications and teeth with straight root canal (verified radiographically).

METHODOLOGY:

This study included 30 single-rooted mandibular premolars with mature apices extracted for therapeutic reasons. Decoronation was done at cemento-enamel junction to create a standardised length of roots. A size 10 stainless steel endodontic K-file was used to negotiate the root canal until the tip of the file was seen at the apical foramen. Radiographs were taken to confirm the working length, which was calculated by subtracting 1 mm from the initial length. The root canals were prepared with the Protaper gold file system in a crown down sequence to master apical file size F4. At each instrumentation change, 2 ml 0.5% NaOCL was used for irrigation and was finally rinsed with 1 ml 17% EDTA for 60 seconds. The root canals were dried with paper points and filled with aqueous radiopaque Calcium Hydroxide paste having pH of 12.5, with size # 35 Lentulo Spiral on a contra-angle 1:1 hand piece at a speed of 5000 rpm. Complete placement of water based Calcium Hydroxide inside the canals was eventually confirmed by radiographs taken in mesio-distal and bucco-lingual angulations. After the placement, the coronal access was sealed by Cavit temporary filling material. All specimens were stored in 37 degree C at 100% relative humidity for 1 week. After this period, the coronal access was opened and the removal of water based Calcium Hydroxide was done by different techniques.

In Group 1 removal was performed with conventional irrigation using a plastic syringe with a 30-G needle with 2 ml 0.5% NaOCL followed by Master apical file (protaper file system F4) to the Working length. Canals were irrigated again with 2 ml 0.5% NaOCL and finally with 3 ml 17% EDTA for 60 seconds.

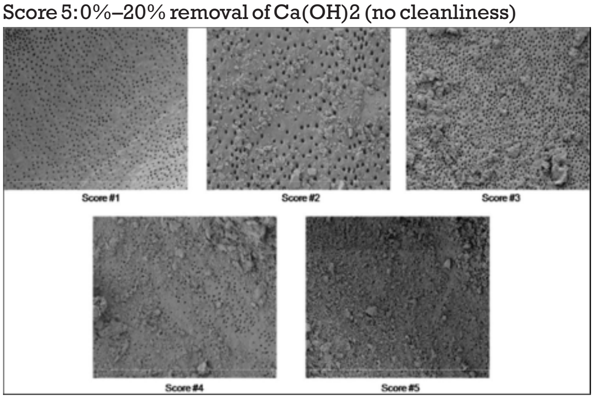
In Group 2 removal was performed by Ultrasonic continuous irrigation using the Pro ultra Piezo Flow Ultrasonic Irrigation Needle. The needle was used in conjunction with a piezo-electric ultrasonic energy-generating unit to provide the energy for tip oscillation. The canal were irrigated with 2 ml 0.5% NaOCL and finally with 3 ML 17% EDTA for 60 seconds.

After removal, roots were grooved vertically on the buccal and lingual surfaces using a water- cooled diamond disk and taking care to avoid touching the root canal to prevent canal contamination. Next the teeth were split into two halves longitudinally with a chisel and mallet and each half then split into coronal, middle and apical thirds in 3 levels at 4, 8, and 12 mm from the root apex, respectively. The cleanliness of the canal wall was evaluated through a scanning electron microscope.

OUTCOME: EVALUATION OF CLEANLINESS

The scoring procedure will be performed by 2 calibrated and blinded evaluators trained in the evaluation procedure using the following 5-grade scale (according to Sami Alturaiki, Hebah Lamphon, Hadeel Edrees and Michael Ahlquist J Endod 2015;3.):

Score 1: 80%–100% removal of $Ca(OH)_2$ (total cleanliness)
Score 2: 60%–80% removal of $Ca(OH)_2$ (great cleanliness)
Score 3: 40%–60% removal of $Ca(OH)_2$ (partial cleanliness)
Score 4: 20%–40% removal of $Ca(OH)_2$ (light cleanliness)
Score 5: 0%–20% removal of $Ca(OH)_2$ (no cleanliness)



Statistical Analysis

The collected data was tabulated in a spreadsheet using Microsoft Excel 2019 and then statistical analysis was carried out using IBM SPSS Statistics for Windows, Version 26.0. (Armonk, NY: IBM Corp). Graphs, Box plots and Pie diagrams were constructed using the GraphPad Prism for Windows, Version 9.0 (GraphPad Software, La Jolla California USA). A Shapiro-Wilk's test and a visual inspection of the histograms, normal Q-Q plots and box plots showed that the collected data were skewed for both the groups. Descriptive statistics were used to report the values of central tendency (median) and measures of dispersion (inter- quartile range). Non-parametric tests were carried out for inferential statistics. Within-group comparisons were carried out with the Friedman's analysis of variance (ANOVA) with the *post-hoc* Dunn's test and between groups comparisons were carried out with the Mann- Whitney U test. The P value of ≤0.05 was considered as the level of significance.

RESULTS

Table 1: Descriptive Statistics [Median (Inter Quartile Range)] Of The Cleanliness Scores For Both The Modalities Of Calcium Hydroxide (CH) Removal At All Levels

Groups	Levels		
	Coronal 3^{rd}	Middle 3^{rd}	Apical 3^{rd}
MAF	2(2-2) ^{a1A3}	3(2.75-3) ^{b1A4}	4(3-4) ^{c1A5}
Ultrasonic	1(1-2) ^{a2B3}	1(1-2) ^{a2B4}	3(2-3) ^{b2B5}

1:MAF; 2:Ultrasonic ;3:Coronal 3^{rd} ;4:Middle 3^{rd} ;5:Apical 3^{rd}

Different lowercase superscript letters denote a statistically significant difference within the group/within levels of cross-section

Different uppercase superscript letters denote a statistically significant difference between two groups ($P<0.01$)

Table 2: Comparison Of Difference Between The Mean Scores At Different Levels Of Cross- Section For MAF By Friedman's ANOVA And The *Post-hoc* Dunn's Test

Dunn's multiple comparisons test	Mean rank diff.	Adjusted P Value
Coronal 3^{rd} vs Middle 3^{rd}	-10.5	0.03*
Coronal 3^{rd} vs Apical 3^{rd}	-25.5	<0.0001**
Middle 3^{rd} vs Apical 3^{rd}	-15.0	0.0185*

*: statistically significant ($P<0.05$); **: Highly statistically significant ($P<0.01$)

The increasing order of the mean cleanliness scores in the MAF group was as follows: Coronal 3rd > Middle 3rd>Apical 3rd. Analysis with Friedman's ANOVA revealed that a statistically significant difference existed between the groups ($P<0.0001$).

Further comparisons by the *post-hoc* Dunn's test implied that the mean cleanliness scores of the Apical 3rd were significantly higher than the Coronal 3rd ($P<0.001$) and the Middle 3rd ($P=0.02$) respectively. Also, there was a statistically significant difference between the Coronal 3rd and the Middle 3rd scores ($P=0.03$).

Table 3: Comparison Of Difference Between The Mean Scores At Different Levels Of Cross- Section For Ultrasonic Activation By Friedman's ANOVA And The *Post-hoc* Dunn's Test

Dunn's multiple comparisons test	Mean rank diff.	Adjusted P Value
Coronal 3^{rd} vs Middle 3^{rd}	-16.5	0.99ns
Coronal 3^{rd} vs Apical 3^{rd}	-45.0	<0.0001**
Middle 3^{rd} vs Apical 3^{rd}	-28.5	0.007**

ns:not statistically significant($P>0.05$);*:statistically significant($P<0.05$);**:Highly statistically significant($P<0.01$)

The increasing order of the mean cleanliness scores in the Ultrasonic group was as follows: Coronal 3rd > Middle 3rd>Apical 3rd. Analysis with Friedman's ANOVA revealed that a statistically significant difference existed between the groups ($P<0.0001$).

Further comparisons by the *post-hoc* Dunn's test implied that the mean cleanliness scores of the Apical 3rd were significantly higher than the Coronal 3rd ($P<0.001$) and the Middle 3rd ($P=0.007$) respectively. However, the difference was only indicative and no statistically significant difference was found between the Coronal 3rd and the Middle 3rd scores ($P>0.05$).

Thus it can be inferred that concerning the removal of Water-based CH, both the devices were capable of cleaning the coronal third and the middle third significantly better than the apical third.

Inter-group comparisons were carried out using the Mann-Whitney's U test and it revealed that the mean cleanliness scores of the MAF were significantly higher than the Ultrasonic devices for all three cross-sectional levels ($P<0.001$)

DISCUSSION

The fundamental criteria required for the success of endodontic therapy include correct diagnosis, thorough cleaning and shaping and three-dimensional obturation of the root canal space with biocompatible and dimensionally stable filling material (16).NaOCl is antimicrobial, helps to lubricate the canals, is relatively inexpensive, has an extended shelf life, dissolves organic tissue and increases dentin tubule permeability (17).

Usually smear layer has been removed by Ethylene Diamine Tetraacetic Acid (EDTA) (18). These agents interact with calcium ions which are present in the dentin wall and form soluble calcium chelates (19).

The present study was conducted on single rooted teeth with straight canals because of less complex anatomy, which leads to better standardization. Also, decoronation was done in order to achieve standardized working length and to eliminate the effect of different factors like crown and pulp chamber anatomy.

Hermann's introduction of calcium hydroxide in 1930 started a new epoch in the field of Dentistry (20). Calcium Hydroxide is used as an intracanal medicament in this study because it is the most popular intracanal medicament to date, owing to its well-documented antibacterial efficacy in the root canal. (Law and Massner, 2004) (21)..Pure Calcium Hydroxide paste has an alkaline pH (approximately 12.5-12.8) and is classified chemically as a strong base. Its main actions are achieved through the ionic dissociation into Calcium and Hydroxyl ions and their effect on vital tissues, the induction of hard-tissue deposition, and the antibacterial properties (22) The lethal effects of Calcium Hydroxide on bacterial cells are likely due to protein denaturation, damage to DNA and cytoplasmic membranes (23).

The most effective methods of calcium hydroxide application to achieve maximum contact with the canal walls is with the help of a Lentulo spiral, McSpadden compacters, files, paper points and placement with a syringe itself (24). In the present study, Lentulo spiral was used to achieve maximum contact with dentinal walls.

Calcium Hydroxide remnants can reduce canal permeability by promoting the formation of calcium carbonate particles and interfering with the sealing ability of endodontic sealers (25). It should be completely removed before root canal obturation because any remnants on the canal walls may influence dentin bond strength and negatively affect the quality of the root filling and microhardness of the root canal dentin.Although various irrigants and methods have been proposed for the removal of Calcium Hydroxide dressings, there is still no general consensus about the optimal technique (26). The most frequently described method for Calcium Hydroxide removal from root canals is instrumentation with the master apical file (MAF) combined with copious irrigation of NaOCl and EDTA (25).

It has been shown that the irrigation material, combined with ultrasonic vibration, is directly associated with the removal of organic and inorganic debris from the root canal walls. A study by Van der Sluis & Versluis showed that the most effective method of calcium hydroxide removal was the use of ultrasonic system along with NaOCL (27).

In the present study, complete removal of calcium hydroxide from the canal walls was not attained under any of the tested conditions, and remnants of calcium hydroxide were found in both experimental groups.

The present study revealed that under Group 2 (Water based Calcium Hydroxide removed by Passive Ultrasonic Irrigation) have better Calcium Hydroxide removal at all three levels, i.e., coronal, middle, and apical thirds of the canal, compared with Group 1 (Water based Calcium Hydroxide removed by MAF). The better result with ultrasonic can be due to its mechanism of action, which is acoustic streaming (28). When placed passively in a canal, acoustic streaming via ultrasonic activation has been shown to produce enough shear force to dislodge debris and Calcium Hydroxide residues from canal walls (28). Acoustic streaming is generated by a nonlinear acoustic wave with a finite amplitude propagating in a viscid fluid. The fluid volume elements of molecules, *V*, are forced to oscillate at the same frequency as the incident acoustic wave. Due to the nature of the nonlinearity of the acoustic wave, the second-order effect of the wave propagation produces a time-independent flow velocity (DC flow) in addition to a regular oscillatory motion (AC motion). Consequently, the fluid moves in a certain direction, which depends on the geometry of the system and its boundary conditions, as well as the parameters of the incident acoustic wave. The small scale acoustic streaming in a fluid is called "microstreaming".

The apical third exhibited higher amounts of residual Calcium Hydroxide than the middle and coronal thirds in both tested groups disregarding the removal technique used. This result is related to the accumulation and transfer of residual Calcium Hydroxide to the apical region, which has a smaller canal area and smaller volume of irrigation solutions, as well as to theanatomic complexity of the apical third. The action and circulation of irrigants may therefore be hindered (29).

CONCLUSION

In the present study, complete removal of calcium hydroxide from the canal walls was not attained under any of the tested conditions and remnants of Calcium Hydroxide were found in both experimental groups.

When comparing two different techniques used in this study for Calcium Hydroxide removal, Ultrasonic irrigation device group showed greater efficiency than MAF at all the three root levels i.e., coronal, middle, and apical thirds of the canal.

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