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COMPARATIVE EVALUATION OF EFFICACY OF DIFFERENT IRRIGATION TECHNIQUES ON REMOVAL OF CALCIUM HYDROXIDE FROM ROOT CANALS: AN IN VITRO STUDY

Dental Science

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ABSTRACT

Aim: To compare and evaluate the efficacy of different irrigation techniques in removing calcium hydroxide from apical third of root canal.

Materials and methods: Root canals of forty five single rooted mandibular premolars were prepared using rotary ProTaper upto F3. The roots were split longitudinally and a groove made in apical third and filled with calcium hydroxide powder mixed with distilled water. The two halves were reassembled and irrigation was done as per the study protocol. The specimen were disassembled and examined under stereomicroscope for the amount of remaining calcium hydroxide in the groove.

Result: No significant difference was found between passive ultrasonic irrigation (Endosonic PS tips) and Laser Activated irrigation (Er,Cr:YSGG Laser)in removing calcium hydroxide from root canals but significant difference was found when compared to needle irrigation.

Conclusion: Endosonic PS tips and LAI was superior in removal of calcium hydroxide from root canals as compared to needle irrigation though none of them could completely remove the medicament.

KEYWORDS

Calcium Hydroxide, Lasers, Ultrasonic

INTRODUCTION

Successful endodontic therapy depends on complete debridement of root canals but due to complex root canal anatomy bacteria may still remain in the canal extension, and isthumses and multiply in between visits, thus to reduce this bacterial count antibacterial medicament is used.

Calcium hydroxide is still the most commonly used endodontic medicament since its introduction by Herman in 1920s. It has low solubility in water, high pH (approximately 12.5–12.8), anti-bacterial action and is insoluble in alcohol. It kills bacteria by direct contact through pH effects, and hence should ideally be placed deep and densely especially in the apical regions and in a sufficient quantity to exert its biological effect.[1]

However, if not completely removed, its presence on the dentin walls could compromise the endodontic treatment.[1] Calcium hydroxide remnants affect the sealing ability of root canal sealers as it can result in a thicker non-homogenous appearance of root canal sealers, accelerates the setting of zinc oxide eugenol sealers which results in cracks in it, prevent sealer from penetrating the dentinal tubules by forming calcium eugenolate and also hinders penetration of resin based sealers resulting in leakage of root fillings on the long term.[2,3] The most critical areas where the remnants are left behind even after instrumentation are the canal extensions or irregularities especially in apical third and can be removed only by irrigation.

The purpose of this study was to evaluate and compare these different techniques, like routinely used syringe irrigation, Laser Activated irrigation (LAI) and Passive Ultrasonic Irrigation (PUI) using newly introduced Endosonic PS tips, in effectively removing calcium hydroxide from root canals. Null hypothesis was that there is no difference between the techniques.

MATERIALS AND METHODS

Forty five human mandibular premolars extracted for orthodontic reasons and those with mature apices and single straight root and single canal (confirmed by radiograph) were selected and stored in distilled water until use. The specimens were decoronated to obtain a standardized root length of 17 mm using diamond disc. The working length was determined by subtracting 1 mm from the length at which the tip of a size 10 K-file (Dentsply Maillefer, Switzerland) extruded apically. Root canal shaping was carried out using ProTaper Universal rotary instruments (Dentsply Maillefer, Switzerland). The instrumentation sequence was: Sx, S1, S2, F1, F2, and F3. The root canals were flushed with 1 mL of 5.25% NaOCl solution between each instrument change.

Roots were mounted in self cure clear acrylic resin using a custom made putty mould. Two horizontal lines were drawn on the specimen which would help in accurate re-approximation later. Longitudinal grooves were made on the buccal and lingual surfaces avoiding penetration into the root canal and roots were split into two halves with a small chisel and mallet. A longitudinal groove of approximately 3 mm long, 0.2 mm wide and 0.5 mm deep was then cut in the root canal wall of one half of each specimen at a distance of 2–5 mm from the apex with a scaler tip adapted on an ultrasonic device (Satelec P5 Booster) to simulate an un-instrumented canal extension in the apical region.

Debris were removed, powder of pure Ca(OH)2 (D P , India) was mixed with distilled water in 1:1 ratio, and the grooves were filled with Ca(OH)2 paste. The root halves were reassembled with the help of sticky wax taking the marked horizontal lines as reference and access temporarily sealed with a cotton pellet and Cavit (Espe, Seefeld, Germany). Specimens were kept at 37°C with 100% humidity, in an incubator for 1 week to simulate inter-appointment dressing and then divided randomly into three groups (n = 15) defined by irrigation technique.

Group I (n=15) - Needle irrigation:

Specimens were subjected to an indigenous method where needle irrigation was done using side vented 30 gauge needle (NaviTip; Ultradent) and 5.25% sodium hypochlorite (NaOCl) and biomechanical preparation one size larger was done with F4 (size 40, 0.06 taper) ProTaper universal rotary file. The needle was placed at a distance of 1 mm from working length, and moved backwards and forwards. Total 5ml of NaOCl was used for 60 sec for each sample followed by flushing with 5ml of EDTA for 60 sec.

Group II (n=15) – Passive ultrasonic irrigation:

Endosonic PS tips (EMS type, Korea) mounted on a piezoelectric ultrasonic unit (EMS) were used with the power setting at 6. 1 mL of 5.25% NaOCl was placed into the root canal, and then the ultrasonic tip was placed into the canal 1 mm short of the working length and without touching the walls. The file was activated for 20s and used in pumping motion. When the irrigating solution in the coronal reservoir decreased, it was refreshed. Total agitation time of 60 s with a total 5ml of 5.25% NaOCl followed by flushing with 5ml of 17% EDTA for 60 sec.

Group III (n=15) –Laser activated irrigation:
NaOCl was activated by Laser irradiation (Er,Cr:YSGG Laser; Waterlase Millenium, Biolase, San Clemente, CA) using an endodontic fibre(Z2, Endolase Tip, Biolase) with a diameter of 200µm and 25mm length, with pulse energies of 75mJ at 20 Hz. 1ml of 5.25% NaOCl was placed into the canal, then the optical fibre tip was placed into the canal about 5mm short of the working length and activated for 20 s. When the irrigating solution in the coronal reservoir decreased, it was refreshed. Total activation time of 60 s and with a total volume of 5.25% NaOCl of 5 mL, followed by flushing with 5ml of 17% EDTA for 60 sec.

Following each irrigation procedure, the root canals were given a final flush with 5 mL distilled water, dried with paper points and disassembled to evaluate the removal of the Ca(OH)2. Digital images at 15X magnification were obtained using a Stereomicroscope (Wuzhou New Found Instrument Co. Ltd, China, Model: XTL 3400E,). Image Analysis System (Chroma Systems Pvt Ltd. India, MVIG 2005) was used to calculate the Ca(OH)2 remaining on the artificially created grooves as a percentage of the overall groove surface.

RESULTS

One way ANOVA test (fig. 1) showed statistically significant difference between the three groups (p value: <0.001). Tukey's post hoc analysis (Table 1) found significant difference between Group I and Group II (p value: 0.008) and Group I and Group III (p value: <0.001). No significant difference was found between Group II (PUI) and Group III (LAI) (p value: 0.572).

FIGURE 1:Comparison of the efficacy of different irrigation techniques on removal of calcium hydroxide from root canal in terms of {Mean (SD)} using ANOVA test (showing percentage of remaining CaOH)

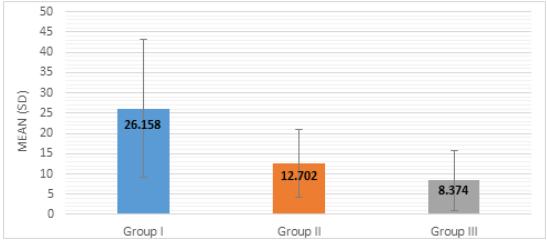


Table 1 (Tukey's post hoc analysis)

	Group I	*Group II*	*Group III*
Group I	-	**0.008***	**<0.001****
Group II	**0.008***	-	0.572
Group III	**<0.001****	0.572	-

DISCUSSION

Bacteria and their by-products play an essential role in pathogenesis of pulpo-periapical diseases. In a long standing infection bacteria propagate in the entire root canal system including ramifications, isthumuses, apical delta and dentinal tubules. Till date no root canal instrumentation technique have been proved effective to completely clean the root canal system especially in narrow, oval, curved or flattened roots.[4] Therefore medicaments are placed in the root canals between visits to help reduce levels of viable bacteria.

Calcium hydroxide has been extensively used as intra-canal dressing because of its antibacterial, anti-resorptive, tissue dissolving and osteogenic potential. It has a high pH of 12, as a result of free hydroxyl ions, this alkalinity is necessary for bone and dentin formation. Therefore calcium hydroxide should ideally be placed deep and densely in canal space, especially the apical third where maximum canal ramifications are seen, in close proximity to appropriate tissues.

All inter-appointment dressings should be removed from the root canal prior to filling to obtain the best interface possible between the canal walls and the filling material[5] which helps in better penetration of root canal sealers into dentinal tubules and obtain a hermetic seal.[6,7,8]

Irrigation is an essential part of a root canal treatment as it allows for cleaning even those areas which are inaccessible to routine instrumentation. Therefore in this study we tested the different irrigation techniques for their effectiveness in removing calcium hydroxide from the canals. The experimental set-up of this study is similar to that described by Lee et al. (2004) The dimensions of the artificial groove was comparable to an apical oval root canal.[9] The advantage of the groove model is firstly, the standardization of size and location of the grooves containing comparable amounts of medicament before irrigation, and also confirming canals to be free of debris before a removal technique is employed.

The results of this study showed that none of the irrigation technique could completely remove the calcium hydroxide paste from the standardized groove made in apical third of root canal. The amount of calcium hydroxide remaining after needle irrigation (group I) was 26.158%, while that with PUI (group II) and LAI (GROUP III), was 12.702% and 8.374% respectively.

Needle irrigation is a routine clinical procedure but unfortunately, it is not effective in the apical part of the root canal, isthmuses or oval extensions. In this study also instrumentation with one file larger than master apical file and needle irrigation with side vented 30 gauge needle (NaviTip; Ultradent) was found to be least effective as the flushing action is relatively weaker. This is in accordance to previous studies by Porkaew et al, T.Abou-Rass and Piccinino ,Cunningham et al. (1982), Goodman et al. (1985), Wu & Wesselink (2001), and Walters et al. (2002)

Ultrasonic activation of irrigant removes more dentin debris and organic tissue from inaccessible root canal areas. An ultrasonic device converts electrical energy into ultrasonic waves by either magnetostriction or by piezoelectricity. Piezoelectric ultrasonic unit EMS was used in this study. Passive ultrasonic irrigation (PUI) was first described by Weller et al. (1980) where canal shaping is not undertaken. Energy from an ultrasonically oscillating instrument (frequency 25-30 kHz) activates the irrigant inside the root canal resulting in acoustic micro-streaming and cavitation. The resultant high velocity of irrigant flow flushes out calcium hydroxide from root canals.

Endosonic PS tips EMS type (Select D, Korea) have been developed by Kim Pyeong-shik. This is the first study conducted with these tips to evaluate its efficacy in removing calcium hydroxide from apical third of root canals. The tip was placed 1- 1.5 mm short of working length and used in slow pumping motion and the irrigant was continuously replenished which enhances the flushing. These tips are non-cutting and flexible so can be used even in curved canals. Made of 'PEEK' (polyether ether ketone) material, it has a very low possibility of deformation and excellent chemical resistance. It is claimed that it can be used continuously at 250˚C and maintain high mechanical properties even at 300˚C. Although further studies are required to establish its efficiency.

Laser-activated irrigation (LAI), using an erbium, chromium: yttrium–scandium–gallium–garnet (Er,Cr:YSGG) laser (Waterlase Millenium, Biolase, San Clemente, CA) at a wavelength of 2780nm was used and was found to be superior to needle irrigation (p value: <0.001). Although no statistically significant difference was found between Group II (PUI) and Group III (LAI) (p value: 0.572). Erbium laser is highly absorbed by water and hydroxyl ions in tooth dentin.[10,11] LAI is based on photoacoustic and photomechanical phenomena. It was used at sub ablative levels and hydration of root canal was maintained by continuously replenishing the irrigant.

The Er,Cr:YSGG laser emits its energy in pulses of about 130 microseconds long. At the beginning of the laser pulse, the energy is absorbed by molecules of water/irrigant in the canal, and super-heated to turn into vapour which expands at high speed forming bubbles that have a volume about 1,600 times the original volume. The continuous passage of laser light through the bubble evaporates the water surface at the front of the bubble referred to as "the Moses effect" by Van Leeuwen et al.[12]

At the end of pulse, the vapour starts cooling, creating a lower pressure inside the bubble. Surrounding liquid rushes in causing bubble implosion, creating microjets in the fluid aimed at the wall with very high forces locally thus flushing off the calcium hydroxide remnants effectively.

However this is an in vitro study and it may be quite different from the biological root canal system and the variations in canal morphology

which could affect the efficacy of the different irrigation systems used in vivo. Also this study did not address the medicament that might have penetrated the dentinal tubules. Hence further studies are recommended that could address these issues.

CONCLUSION

Within the limitations of the study it was found that none of the irrigation technique followed could completely remove the calcium hydroxide paste from the artificial groove in the apical third. Although Laser Activated Irrigation (LAI) and Passive Ultrasonic Irrigation (PUI) showed superior results than the needle irrigation group.

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