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Comparative evaluation of different techniques in calcium hydroxide removal from root canals by scanning electron microscope: An *in vitro* study

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Abstract
Objectives: a) to evaluate the efficacy of various instruments in removal of $Ca(OH)_2$ from the root canals. b) to find out the best instrument or technique out of all five experimental groups. c) to access the inter group comparison among them.
Methodology: For this study 70 teeth were selected from an adult population with sufficient crown, complete roots and fully formed apices. Following that root canal preparation was done using Protaper Universal rotary system upto F4 (#40, 6% taper) using Avue Prep (Dental Avenue, India) and 5 ml of 3% sodium hypochlorite with 17% EDTA. Following that, calcium hydroxide paste was then inserted and retrieved by different instruments.
Result: In the coronal third, passive ultrasonic irrigation method and that of master apical file performed better than the other groups. In the middle third, the cleaning efficacy was better for passive ultrasonic irrigation followed by navitip fx, master apical file, canal brush. In the apical third, passive ultrasonic irrigation method outperformed other groups.
Conclusion: Even though none of the techniques used in this study completely removed the CH from the root canals. But passive ultrasonic irrigation technique proved a way ahead than the other methodologies.

Keywords: Different techniques, techniques in calcium hydroxide removal

Introduction
Successful root canal treatment is based on establishing an accurate diagnosis and developing an appropriate treatment plan. Unfortunately, one of the neglected phase of endodontic treatment is the eradication of microorganisms and complete removal of minute fragments of organic debris, necrotic tissue, pulp remnants and dentinal shavings from the root canal [1]. Although there are many antimicrobial intracanal medicaments used abundantly but calcium hydroxide [2] is universally tried and widely used due to its bactericidal and biological properties. But, it must be gradually replaced and completely removed from the canals before obturation as its remnants may jeopardise the prognosis of endodontic therapy. Therefore, the present study is designed to compare the effectiveness of irrigating solutions, master apical file, Canal Brush technique, passive ultrasonic irrigation and navitip fx tip in removing $Ca(OH)_2$ from the root canal system by using the scanning electron microscope (SEM).

Literature search
The Cochrane Controlled Trials Register was searched using the terms "$Ca(OH)_2$ paste removal from root canals." The optimum search strategy was combined with the above-mentioned terms and used to search MEDLINE from 1983 to 2015. A similar search was undertaken on Embase (1988–2013) and Health STAR. No language restriction was applied to the search. A total of 94 studies were analyzed.

Materials and methods
This study was conducted as a clinical trial in the Department of Conservative Dentistry and Endodontics, Regional Dental College, Guwahati, Assam. 70 teeth were selected for this study and it was approved by Institutional Ethics Committee.
Seventy teeth were collected from such collection using following parameters:

1. The teeth were from an adult population with sufficient crown, complete roots and fully formed apices. Teeth having root caries or which were attempted previously for endodontic procedure were excluded. They were selected irrespective of the sex or the general health of the patient.
2. The teeth were screened by pre-operative radiographs:

- Single canal within root (confirmed from the radiograph taken from labiolingual and mesiodistal direction) are selected.
- Teeth with external/ internal resorption were kept out of the study.

Preservation of samples

The selected teeth were then stored in 3% sodium hypochlorite for 24 hrs to remove any remaining organic debris. They were then washed under tap water and stored in normal saline.

Methodology

For this study crowns of the teeth were removed 14 mm from the apex to standardize their length. The working length was established using K-files #10 such that it was 1 mm short of the apical foramen which was confirmed radiographically. Following that root canal preparation was done using Protaper Universal rotary system upto F4 (#40, 6% taper) using AvuePrep (Dental Avenue, India) and 5 ml of 3% sodium hypochlorite with 17% EDTA [3-6] for 1min for final flush. Finally, the teeth were randomly assigned into seven groups (n=10) Following that, chemically pure calcium hydroxide powder was mixed with distilled water in 1:1 ratio of volume. The paste was then inserted using # 30 lentulo in all the samples except negative controls. Cotton pellets were then placed in all canal orifices and teeth were temporarily restored with zinc oxide eugenol cement. Afterwards, mesiodistal and buccolingual radiographs were taken to confirm complete filling. All teeth were then kept in 100% humidity for 1 week at 37° centigrade in an incubator. One week later, the samples were retrieved and temporary restorations were removed. Following that, different techniques were then used to remove calcium hydroxide from the root canals of experimental groups. However, no attempt was made to remove the paste from the samples comprising the positive controls

Group I: Root canals were cleaned using 15, 20 size K file with circumferential motion followed by shaping with Protaper rotary uptil F4. Recapitulation was equally carried out with simultaneous irrigation by 5 ml of 3% sodium hypochlorite. This was followed by a final rinse of 17% EDTA solution.

Group II: Here, only sodium hypochlorite and EDTA solutions were used for irrigation to draw out calcium hydroxide paste from teeth samples.

Group III: Here, initially root canals were cleaned using K files with circumferential motion followed by NaOCl and EDTA irrigation. Then a medium sized micro brush (Roeko CanalBrush™, Coltene Whaledent) was introduced inside. The brush was attached to a contra-angled micro-motor hand-piece running at 600 rpm and advanced to the working length for a time period of 30 seconds. This was followed by same irrigation protocol.

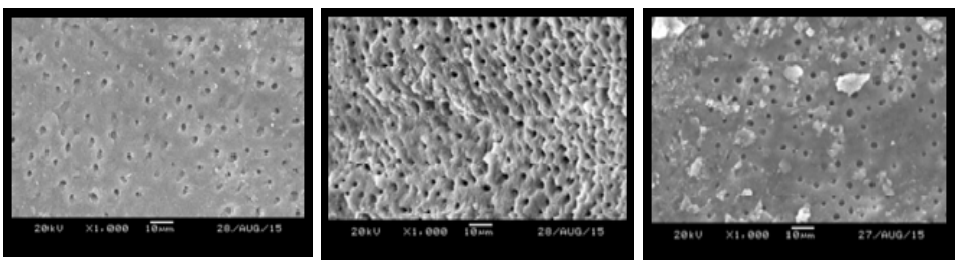
Group IV: Here, 15 K file was used to drill the $Ca(OH)_2$ paste. Then 15 no. U- file fitted on the endomode of ultrasonic scaler handpiece was activated for 10 seconds and advanced to the full working length followed by copious irrigation.

Group V: Here, the irrigation was done with #30-gauge NaviTip FX tip (Ultradent Products Inc, South Jordan, UT) fitted on the body of 2.5 ml disposable syringe. The procedure was aided by same irrigation protocol as for the rest.

Group VI: It comprises the control group. Intracanal medicament was placed in the positive control group without subsequent removal. The negative control did not receive any calcium hydroxide paste.

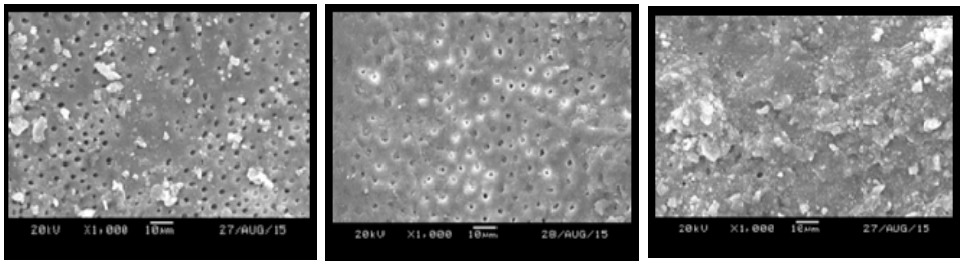
After instrumentation, the roots were grooved vertically on the buccal and lingual surfaces, using a water coolant diamond bur taking care to avoid touching the canal wall. All roots were then split in the buccolingual direction using a chisel and mallet and each sample divided into three equal parts as apical, middle and coronal thirds by making small grooves with a sharp knife on the side of the root. The disc was used to fascilitate easy splitting by a hand chisel and mallet. Care was taken not to allow the disc to come in contact with the canal surface to prevent any splattering. The sections were evaluated and to standardize the result, the cleaner halves were selected. The selected dentinal surfaces were marked at 3 mm, 6 mm and 9 mm from the apical end and was viewed at a point equidistant from the lateral walls. The samples were dehydrated by a series of graded ethanol solutions and then coated with a gold layer after which they were evaluated using the SEM (JEOL JSM-6360, Japan) at 1000X magnification. To standardize the area examined for each sample, the technique described by Paque *et al*. [7] was used. For this purpose, the central beam of the SEM was directed to the center of each third of the root canal by the SEM operator under 10 × magnification. Then the magnification was increased gradually to 1000X and the area of the canal wall captured on the screen of the SEM's monitor unit was used for scoring the sample.

Afterwards, the images were scored according to Hulsmann *et al* [8]



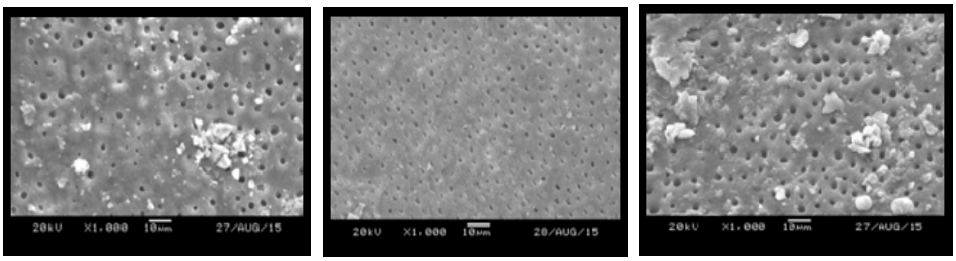
MAF (Coronal/C) MAF (Middle/ M) MAF (Apical/A)

Fig 1: Sem images of master apical file group (protaper)



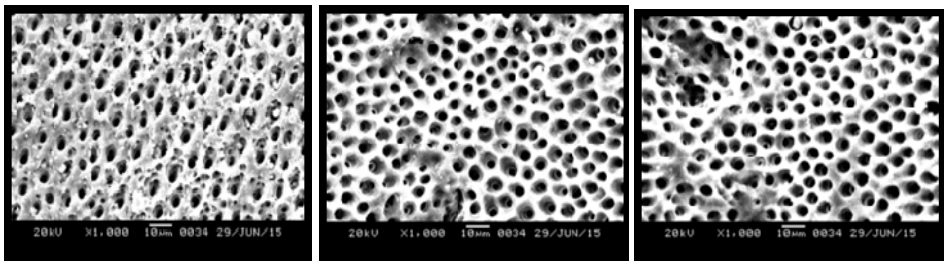
Solution (C) Solution (M) Solution (A)

Fig 2: Sem images of irrigating solutio n group



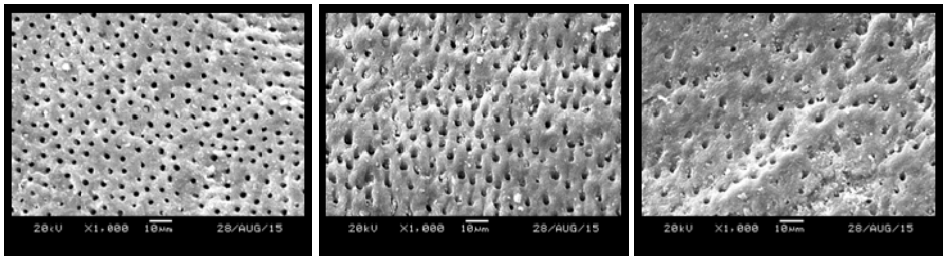
Canalbrush (C) Canal Brush (M) Canalbrush (A)

Fig 3: Sem images of canal brush group



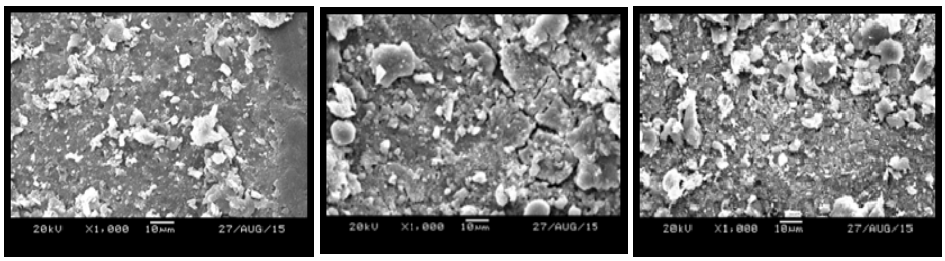
PUI (C) PUI (M) PUI (A)

Fig 4: Sem images of u-file group

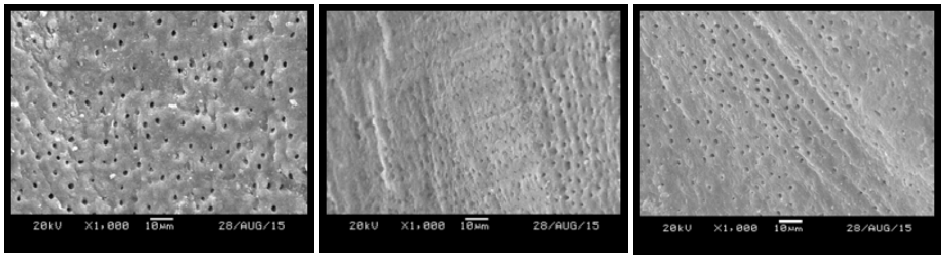


Navitip-FX (C) Navitip-FX (M) Navitip-FX (A)

Fig 5: Sem images of navitip-fx group



Positive GR (C) Positive GR (M) Positive GR (A)



Negative Gr (C) Negative Gr (M) Negative Gr (A)

Fig 6: Sem images of control groups

Statistical analysis

Statistical analysis was done using Microsoft excel and IBM SPSS Version 20 software.

Results

From the Kruskal Wallis test, it can be inferred that in the coronal level, the highest mean rank was found in solution group with a score of 33.95 followed by canal brush with a score of 28.70. Navitip fx group scored 24.10 followed by master apical file group with 21.25 and U-file group with the least score of 19.50.In the middle third, solution group scored the highest mean rank with 35.60 followed by canal brush with 31.80. Master apical file scored 23.45, navitip fx 19.40 and U-file scored the least with 17.25.In the apical third, the highest mean rank was seen in solution group with a score of 35.30 followed by canal brush group with 31.20, navitip fx with 23.00, master apical file group with 20.30 and U-file group with lest score of 17.00.

Discussion

The elimination of microorganisms in the root canal environment prior to obturation is of paramount importance for predictable treatment of apical periodontitis and the literature demonstrates the necessity of using an intracanal dressing to achieve such goal [9-12] Calcium hydroxide-based medications are routinely used in endodontics to eradicate microorganisms from the root canal system as the complex anatomy of the root canal system may lodge such pathogens even after careful instrumentation and irrigation, leading to failure of treatment. The study began with preparation of tooth with rotary files and placement of $Ca(OH)_2$ for seven days. Following that, the medicament was removed by different techniques with NaOCl and EDTA as standard irrigation protocol. For better results, EDTA has been added as it can effectively remove inorganic part of the smear layer. This was supported by Margelos *et al* [13]. The roots were then sectioned longitudinally into two halves. The cleaner halves were selected and each third was scanned under SEM for imaging. Data so obtained was tabulated and statistically analyzed using Microsoft Excel and IBM SPSS software. After evaluating median scores, Kruskal Wallis test was carried out to understand distribution of mean rank of various groups at coronal, middle and apical third respectively. The results obtained showed that no irrigant or method completely removed calcium hydroxide but agitation of the irrigant resulted in cleaner canal walls as compared to conventional syringe irrigation in all the three halves. Even though apical third was the most difficult to clean but agitation with U-file resulted in better cleaning efficacy. This may be attributed to acoustic streaming [14-19] The nodes created on the file transmit energy to the irrigant causing rapid movement of the irrigant and enhancing its ability to penetrate deeper into the canal [20]

In the middle third, the cleaning efficacy was better for passive ultrasonic irrigation followed by navitip fx, master apical file, canal brush. Studies of Keir *et al* [21], which reported use of the Endobrush for improving canal debridement showed that the brush was significantly better than instrumentation alone in debriding the root canal but still not satisfactory. Syringe irrigation with NaOCl and EDTA was the least efficient of all.

In the coronal third, passive ultrasonic irrigation method and that of master apical file performed better than the other groups. The advantage of using the file resulted in agitation of the irrigants which resulted in cleaner apical areas. Such findings co-relate with that of Margelos *et al* [13] and Salgado *et al* [22].

Conclusion

So, it was seen that none of the techniques used in this study completely removed the CH from the root canals. This is in agreement with results of the previous studies, which showed the presence of CH debris on the root canal walls, regardless of the removal techniques. However, passive ultrasonic irrigation technique proved a way ahead than the other methodologies. So, PUI can be taken as an adjunctive treatment for chemo mechanical preparation of the root canal system. Further studies may be required to make a final judgement about the effect of various techniques in removal of intracanal paste.

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