Mandibular Premolar Root Canal Cleaning Efficacy of Ultrasonic and Hand Debridement – A Scanning Electron Microscope Study

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To evaluate and compare the cleaning efficacy of ultrasonic and hand debridement of mandibular premolar root canal using scanning electron microscope. A sample of thirty freshly extracted human mandibular premolar teeth with straight canal was employed in this study. Fifteen teeth were utilized for debridement with hand K files and 2.5 % sodium hypochlorite irrigation in group A. Similar number of specimens was used for ultrasonic debridement with endosonic K files and 2.5% sodium hypochlorite irrigation in group B. The roots were sectioned longitudinally and exposed to scanning electron microscope at cervical, middle and apical third level of the canal. The photomicrographs, obtained, were qualitatively and quantitatively evaluated by three endodontists. The qualitative and quantitative data was statistically analyzed by SND and unpaired t test respectively.

It is revealed that grade I (clean) specimens are obtained only by ultrasonic debridement and Grade V (with severe debris) specimens are obtained only by hand debridement. Higher proportion of grade II photomicrographs is obtained in ultrasonic than hand debridement. Grade III and Grade IV are obtained in higher proportion by hand as compared to ultrasonic debridement. In quantitative analysis, it is seen that ultrasonically debrided specimens are significantly cleaner than the hand debrided specimens ($P < 0.01$).

Key Words: Cleaning Efficacy, Hand debridement, Mandibular premolar root canal, Ultrasonic debridement.

Proper cleaning and removal of intra-canal source of infection are of paramount importance as a precondition to successful root canal treatment. Development in instruments and irrigation techniques reflects the cerebral activity put in by the investigators to improve the cleaning efficacy. Investigators [1,2,3] have generally concluded that hand and mechanical debridement leave debris, both organic and inorganic, within the canal. Ultrasonic debridement combines ultrasonic biological, chemical and physical actions. The multiple effects make it a multi-dimensional system that results in biologically cleaner root canal system.

The aim of this study is to evaluate and compare the cleaning efficacy of hand and ultrasonic debridement of mandibular premolar root canal focused on debris, smear layer, patency of openings of the dentinal tubules and instrument striations using scanning electron microscope.

MATERIALS AND METHODS

Freshly extracted human mandibular premolar teeth with straight roots are collected, radiographed after rinsing with distilled water and stored in saline. Thirty teeth having single straight canal with minimum apical width of size 25 K file, as determined from radiograph, are selected. All the teeth are grooved around the cervical margin of the crown and on the buccal and lingual side of the root by carborundum disc to facilitate sectioning. Adequate care is taken to prevent damage to the root canal surfaces of the teeth. The teeth are divided in to 2 groups i.e. group A and group B comprising of 15 teeth each. Endodontic access preparation is made. Patency and working length for each specimen is established by 15 K hand file.

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Hand debridement

Group A specimens are debrided with K files and 2.5 percent sodium hypochlorite solution. The snug fit of the file in the apical third of the root canal is taken as criteria for selecting the initial file. Subsequently, immediate two sizes of files are used for debridement. The canal is copiously irrigated with 2.5 percent sodium hypochlorite solution by 30 gauge needle and syringe during and after instrumentation.

Ultrasonic debridement

Group B specimens are debrided by circumferential filing with 15 K hand file and 2.5 percent sodium hypochlorite irrigation to ensure patency of the canal. Then endosonic 15, 20 and 25 K files are inserted sequentially and activated without dampening for one minute with simultaneous 2.5 percent sodium hypochlorite irrigation. Subsequently the endosonic 15 K file is activated for two minutes along with ultrasonic irrigation. The power and spray control regulator knobs of ultrasonic unit (Satelec) are adjusted in such a way that the file vibrates along with mist formation just above the tip with continuous swirling of the irrigant along the file.

Preparation of specimens for scanning electron microscope

After debridement, the canals of all teeth are dried with paper points. The crowns are separated with the help of chisel and mallet. The roots are sectioned longitudinally into two parts i.e. mesial and distal with the help of chisel and mallet. One half is selected randomly and other half is discarded. The specimens are dehydrated by dipping them sequentially in 50 percent, 75 percent and 100 percent ethyl alcohol for twenty four hours each. The dried specimens are sputter coated with gold palladium and then exposed to scanning electron microscope. Complete surface of the specimen is scanned. Photomicrographs with magnifications of x-750 and x-1500 are taken at cervical, middle and apical third level of the root randomly. These photomicrographs are evaluated by three endodontists. The observations are tabulated and subsequently subjected to statistical analysis.

Qualitative Evaluation

The photomicrographs are qualitatively evaluated by the following criteria:

1. Overall cleanliness.
2. Presence or absence of the smear layer.
3. Patency of the openings of dentinal tubules.
4. Presence of debris and instrument striations.

Thus the photomicrographs are graded on a scale of I to V as described below: (Fig.1 to 5)

Grade I : Clean without debris and smear layer, presence of patent dentinal tubules and absence of instrument striations.

Grade II: Minimal debris and smear layer, many patent dentinal tubules and absence of striations.

Grade III: Mild debris and smear layer, few patent dentinal tubules.

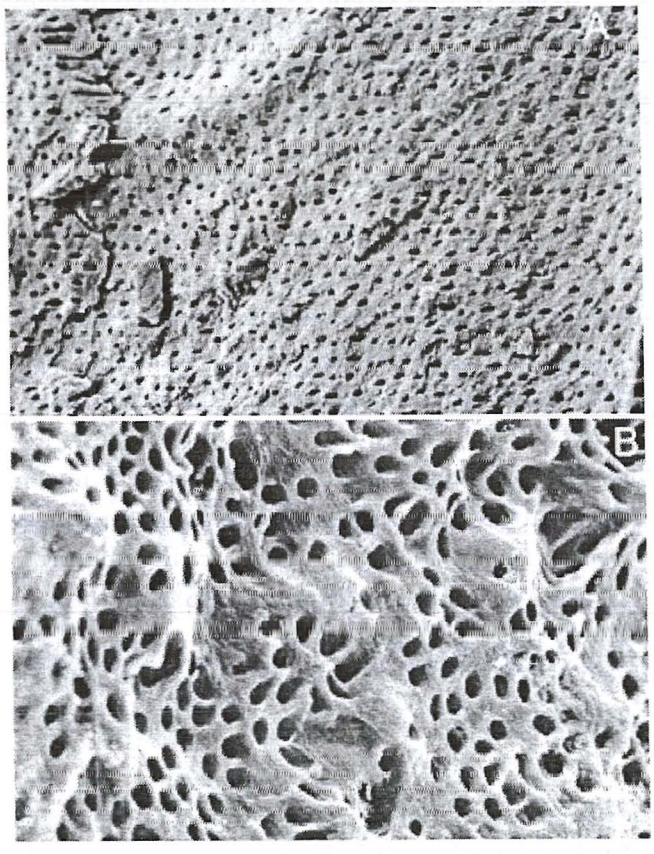


Fig. 1 - Grade I: A. Photomicrograph (X 750 magnification) of ultrasonic debridement specimen Apical part.

B. Photomicrograph (X 1500 magnification) of ultrasonic debridement specimen Middle part.

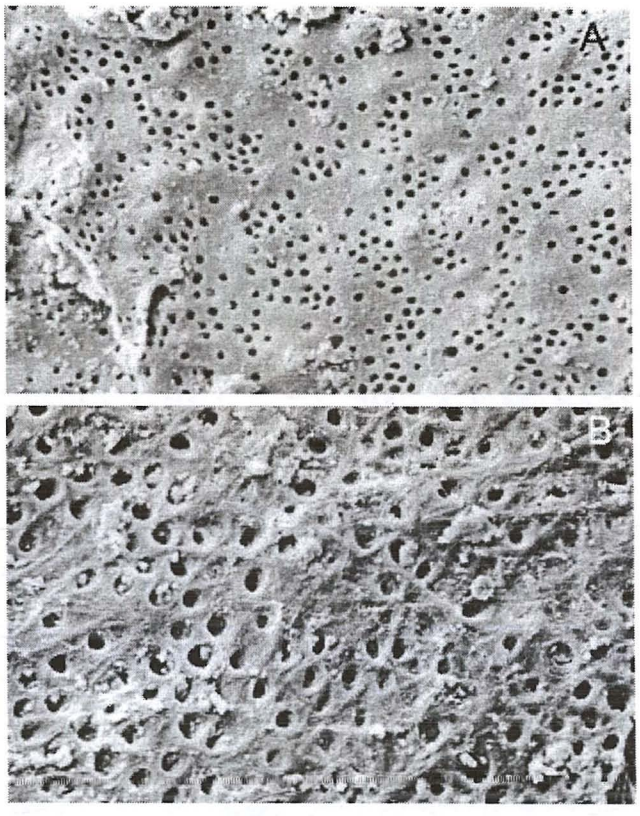


Fig. 2 - Grade II: A. Photomicrograph (X 750 magnification) of ultrasonic debridement specimen Cervical part.

B. Photomicrograph (X 1500 magnification) of ultrasonic debridement specimen Cervical part.

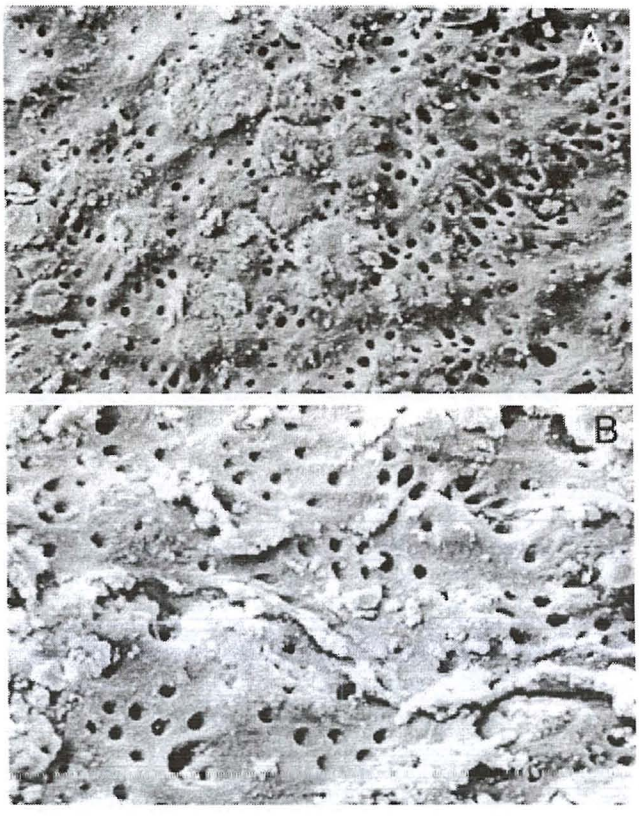


Fig. 3 - Grade III: A. Photomicrograph (X 750 magnification) of ultrasonic debridement specimen Apical part.

B. Photomicrograph (X 1500 magnification) of hand debridement specimen Middle part.

Grade IV: Moderate debris and smear layer, few patent dentinal tubules and presence of striations.

Grade V: Severe debris and smear layers, no patent dentinal tubules and presence of striations.

Quantitative Evaluation

These photomicrographs are rated on a scale of 1 (clean) to 5 (full of debris and smear layer) for canal cleanliness.

RESULTS

Qualitative Analysis

T--able No. 1 -shows that fifteen specimens were studied for cleaning efficacy of hand debridement at three different levels. Out of forty five photomicrographs subjected for analysis, none were shown grade I, five were shown grade II, eleven were shown grade III, twenty were shown grade IV and nine were observed as grade V.

Table No. 2 show the cleaning efficacy of ultrasonic debridement. Fifteen specimens were studied in this group. Out of forty five photomicrographs analyzed, eight were shown grade I, Sixteen grade II, nine grade III, twelve grade IV and none were shown grade V in this category.

The data in table No. 1 and 2 was analyzed statistically by using the standard normal deviate. The values of P_1, P_2, SND and their significance are shown in Table No. 3.

It is seen that grade I (clean) specimens are obtained only by ultrasonic method and none by conventional method. Grade V (with severe debris) specimens are obtained only by conventional method and none by ultrasonic method ($P < 0.001$). Grade II are obtained in higher proportion with significant difference ($P < 0.01$) in ultrasonic method than conventional. Grade III and Grade IV are obtained



Fig. 4 - Grade IV: A. Photomicrograph (X 750 magnification) of hand debridement specimen Apical part.

B. Photomicrograph (X 1500 magnification) of hand debridement specimen Cervical part.

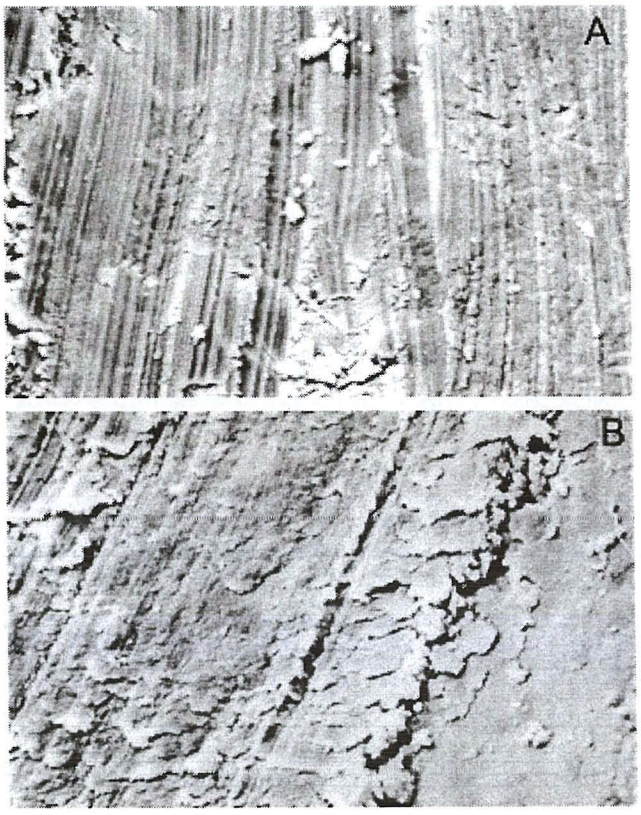


Fig. 5 Grade V: A. Photomicrograph (X 750 magnification) of hand debridement specimen Apical part.

B. Photomicrograph (X 1500 magnification) of hand debridement specimen Middle part.

in higher proportion in conventional method as compared to ultrasonic method (P>0.05).

Quantitative Analysis

These photomicrographs were rated on a scale of 1 (clean) to 5 (full of debris and smear layer) for canal cleanliness (Table no.4). The observations were further statistically analyzed using unpaired 't' test. It is evident from table No. 5 that ultrasonically debrided specimens are significantly cleaner than the conventional ones (P < 0.01).

DISCUSSION

The goal of endodontic debridement procedure is to clean thoroughly all parts of the root canal system eliminating all tissue remnants, antigenic and inflammatory chemicals and bacteria. Irrigation of the root canal serves a number of purposes including removal of debris, canal lubrication, dentin demineralization and antimicrobial action. Although different irrigation solutions have been demonstrated since many years, their efficacies were controversial due to the discrepancies of result reported by various studies.[1,2,3] The usual irrigation methods have been found inadequate in their ability to penetrate, flush and remove debris.[2] Irrigation is commonly applied by a syringe and a needle, with needle sizes varying typically between 27 and 30 gauge i.e. 0.635 and 0.305 mm, respectively. With such a system, irrigation solutions will not travel apically more than 1 mm beyond the tip of the needle.[4,5] Canal size and shape are crucial to the penetration of the irrigant. The apical 5 mm are not flushed until they have been enlarged to size 30 file.[6]

From table no. 1, it is observed that all the specimens studied for hand debridement show debris, smear layer, and non-instrumented areas. Similar

findings are reported by Moodnik et al[7] and Lester et al[8]. Moodnik et al[7] reported that the walls of the root canals were full of inaccessible irregularities and there was debris at all levels with a layer of sludge which covered all instrumented canal surfaces. Lester K.J. et al[8] reported that there was formation of smear layer and the organic component occluded the dentinal tubular openings.

During the course of instrumentation of the root canal, a thin layer of 1 to 4 μm thickness, composed of organic components such as heated coagulated proteins, necrotic or viable pulp tissue, odontoblastic processes, saliva, blood cells, microorganisms and inorganic components consisting of tooth structure and some non specific contaminants, is formed. Since such layer harbors bacteria and is permeable to bacteria products, forms a reservoir of potential irritants.

From table No. 2, it is evident that the ultrasonically debrided specimens show little debris, minimum smear layer with many patent dentinal tubules. In some cases, all the openings of the dentinal tubules remained patent due to total elimination of the smear layer.

Ultrasonic irrigation involves generation of ultrasonic waves which enable the irrigant to pass along the file into the canal. The principal effects of ultrasound in solution are cavitations and acoustic streaming. Ultrasound generates a bubble in the irrigation which grows until implosion occurs with concomitant release of shock waves and force with vacuum effect. This causes the aspiration of debris from canal ramifications such as cul-de-sacs, fins, etc. into main canal which allows easy removal.

Ahmad et al[9] and Lumley et al[10] attempted to measure the cavitational activity around the endosonic file. They concluded that, although some cavitational activity occurred, the main beneficial effects were related to the generation of large hydrodynamic shear stresses by the acoustic streaming. It causes the liquid irrigant to run up and down very close to the file into an irregular eddying of motion most rapidly at the tip causing a radiating pressure that flush debris and bacteria from the canal and also shears bacterial cells making them more vulnerable to irrigant action. Acoustic micro streaming occur along the whole length of the file with the greatest streaming and shear stresses around points of maximum displacement i.c. the tip of the file and other antinodes along its length.

Table 1: Observation for hand Debridement*

Gradations Location	I	II	III	IV	V	Total
C	0	3	3	5	4	15
M	0	1	4	7	3	15
A	0	1	4	8	2	15
Total	0	5	11	20	9	45

*Figures represent the mean value of the observation by three observes (approximated to nearest integer).

Table 2: Observation for Ultrasonic Debridement*

Gradations Location	I	II	III	IV	V	Total
C	2	5	3	5	0	15
M	3	5	4	3	0	15
A	3	6	2	4	0	15
Total	8	16	9	12	0	45

*Figures represent the mean value of the observation by three observes (approximated to nearest integer).

Ahmad et al[11] suggested that the streaming can be increased by holding a freely oscillating file within the canal. They further stressed the orientation of ultrasonic file and its maximum benefit can be derived when the file is oscillating towards the area of the canal to be cleaned. This may be of clinical significance in cleaning of oval canals. Lumley et al[12] studied the streaming patterns occurred around an endosonic file and concluded that the streaming patterns were dependent on the type of the system used, the power output, constraint applied to the file, displacement amplitude and the length of the file. In another study[13], they found substantial differences in the displacement amplitude of the file when same size file was used in different ultrasonic units.

Lea SC et al[14] found that the maximum displacement amplitudes were 17 to 22 μm (#10 file, 27 mm), 15 to 21 μm (#10 file, 31 mm), 6 to 9 μm (#30 file, 27 mm), and 5 to 7 μm (#30, 31 mm) for all power settings. Antinodes occurring along the remaining file length were significantly larger at generator power 1 than at powers 2 through 5 ($p < 0.03$). They concluded that at higher generator powers, energy delivered to the file is dissipated in unwanted vibration resulting in reduced vibration

Table 3: Significance of the difference between hand and ultrasonic debridement specimens and their proportions.

Gradations	Proportion of specimens		Difference between proportion and their significance		
	H(P1)	U(P2)	P1- P2	SND	Significance
I	0.00	0.17	-0.17	-3.03	P<0.001
II	0.11	0.35	-0.24	-2.82	P< 0.01
III	0.25	0.20	0.04	0.458	P>0.05
IV	0.44	0.26	0.18	1.82	P>0.05
V	0.2	0.00	0.2	3.35	P< 0.01

Table 4: Mean score by three observers at cervical, middle and apical third for hand and ultrasonic method specimens

Observers	Cervical		Middle		Apical	
	H	U	H	U	H	U
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
A	3.67 ± 1.05	2.47 ± 0.99	3.8 ± 0.86	2.46 ± 0.91	3.8 ± 0.77	2.06 ± 1.03
B	3.06 ± 1.18	2.73 ± 1.10	3.8 ± 0.86	2.33 ± 0.97	3.6 ± 0.72	2.4 ± 1.12
C	3.67 ± 0.98	2.93 ± 1.22	3.86 ± 0.83	2.46 ± 1.18	3.8 ± 1.01	2.8 ± 1.14
Combined Mean	3.64 ± 1.07	2.71 ± 1.10	3.82 ± 0.85	2.42 ± 1.02	3.73 ± 0.83	2.42 ± 1.11

Table 5. Comparisons between the mean scores of hand and ultrasonic debridement specimens and their significance

Location	Hand	Ultrasonic	t Value	Significance
	Mean ± SD	Mean ± SD		
Cervical	3.64 ± 1.07	2.71 ± 1.10	2.35	P < 0.05
Middle	3.82 ± 0.85	2.42 ± 1.02	4.08	P < 0.001
Apical	3.73 ± 0.83	2.42 ± 1.11	3.66	P < 0.01
Combined Mean	3.73 ± 0.91	2.51 ± 1.07	3.36	P < 0.01

displacement amplitudes. This may reduce the occurrence of the biophysical forces necessary to maximize the technique's effectiveness.

While comparing the ultrasonic debridement with that of the conventional debridement, it can be seen from table No. 3 that the ultrasonically debrided specimens are significantly cleaner than the conventional ones. It is evident from table No. 5 that the difference between the mean scores of hand and ultrasonically debrided specimens are significant at all the three levels i.e. cervical, middle and apical third of the canal ($P < 0.01$).

Van der Sluis LW et al[15] concluded that ultrasonic irrigation of the root canal can be performed with or without simultaneous ultrasonic instrumentation. When canal shaping is not undertaken the term passive ultrasonic irrigation (PUI) can be used to describe the technique. Passive ultrasonic irrigation can be performed with a small file or smooth wire (size 10-20) oscillating freely in the root canal to induce powerful acoustic microstreaming. PUI can be an important supplement for cleaning the root canal system and, compared with traditional syringe irrigation. It removes more organic tissue, planktonic bacteria and dentine debris from the root canal.

Thus, the result of this study, indicate that the ultrasonic debridement in conjunction with 2.5 percent sodium hypochlorite irrigation produces a cleaner canal than conventional debridement. This may be attributed to the effects of an ultrasonic bath, increased volume of irrigation and the increased efficiency of sodium hypochlorite solution all acting simultaneously and synergistically.

CONCLUSION

The following conclusions are drawn from this study:

1) Hand debridement leaves debris and instrument striations in root canal.

   Many of the dentinal tubule openings are plugged with smear layer.

2) Ultrasonic debridement of root canal removed most of the debris and smear layer.

   Many of the dentinal tubule openings are patent.

3) Ultrasonic debridement show better cleaning of mandibular premolar root canal than hand debridement.

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