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A Scanning Electron Microscopic Study of Debris and Smear Layer Remaining Following Use of Greater Taper Rotary Instruments

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ABSTRACT

The aim of this in vitro study was to evaluate the debris and smear layer in the root canal following the use of Ni-Ti ProTaper Hand, ProTaper rotary and Quantec rotary instruments. Forty five freshly extracted single rooted human mandibular premolar teeth were selected. Crowns of all teeth were cut off at the cemento-enamel junction with a separating disc and the roots were randomly divided into three groups of fifteen samples each. Each group was further divided into three subgroups. The working length of all teeth was established by the insertion of endodontic instrument into the canal until its tip is visible at the apical foramen and then by subtraction of 0.5 mm. A sequential crown down instrumentation technique was carried in all the three groups as follows: Group I- ProTaper Ni-Ti hand instruments. Group II - ProTaper rotary instruments. Group III - Quantec rotary instruments. Irrigation was done with 3% sodium hypochlorite and 15% EDTA in all the three groups. Teeth were carefully split and subjected to Scanning Electron Microscopic evaluation for debris and smear layer. Results showed that when comparing Ni-Ti ProTaper hand, ProTaper rotary instruments and Quantec rotary instruments; ProTaper rotary instruments produced the maximum amount of debris and smear layer followed by Quantec rotary instruments, while the ProTaper hand instruments showed the least amount of debris and smear layer.
Keywords: debris, Ni-Ti rotary instruments, root canal preparation, SEM, smear layer.

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INTRODUCTION

Cleaning is one of the main objectives of root canal preparation that not only removes micro-organisms and permits better adaptation of filling material but also enhances the action of intra canal medicaments.

Smear layer is defined by the American Association of Endodontists as a surface film of debris retained on dentin or other surfaces after instrumentation with either rotary instruments or endodontic files and consists of dentin particles, remnants of vital or necrotic pulp tissue, bacterial components and retained irrigant [1]. Debris is defined as dentin chips, pulp remnants and particles loosely attached to the root canal walls [2].

All endodontic instruments create dentin debris and smear layer as a consequence of their action on root canal walls. Along with pulpal remnants, the removal of smear layer and debris from root canal walls is equally important [3]. EDTA in combination with sodium hypochlorite is an excellent combination of irrigants to remove all tissue, necrotic debris, infected pre-dentin and dentin, smear layer as well as softened dentin to great extent in the efficient final cleaning and shaping of the pulp space.

Hand instrumentation of root canals has remained a standard technique for more than five decades and continues to be a standard method of pulp space instrumentation. However, several investigators have demonstrated that rotary systems using nickel-titanium instruments can lead to superior results in the instrumentation of pulp space.

Nickel titanium (Ni-Ti) instruments represent a relatively new approach to the rapid preparation of canals with standardized taper; however, the amount, thickness and type of smear layer produced by different Ni-Ti instruments must be assessed.

Amongst, the various rotary Ni-Ti instruments with different configurations and unique designs that have been marketed, the widely used ProTaper (Dentsply Maillefer) and Quantec rotary instruments (Sybron Endo) have not been evaluated and compared for their ability for debris production and smear layer removal.

The purpose of this study was to evaluate under SEM, the type of smear layer produced by the newer Quantec rotary files and in comparison to the widely used ProTaper hand and rotary instruments.

MATERIAL AND METHODS

Forty five freshly extracted, intact, non-carious and unrestored single rooted human mandibular premolars collected from the Department of Oral and Maxillofacial Surgery, A. B. Shetty Memorial Institute of Dental Sciences, Mangalore were stored, disinfected and handled as per the recommendations and guidelines laid down by Occupational Safety and Health Administration (OSHA) and Centre for Disease Control and Prevention (CDC).

Crowns of all teeth were cut off at the cemento-enamel junction with a separating disc. The roots were then randomly divided into three groups of fifteen samples each. The working length of all teeth was established by the insertion of an endodontic instrument into the canal until its tip was visible at the apical foramen and then by subtraction of 0.5 mm.

A sequential crown down instrumentation technique in combination with 3% sodium hypochlorite and 15% EDTA was performed in the three groups according to the manufacturer's instructions as follows:

Group I - ProTaper Ni-Ti hand instruments.
Group II - ProTaper Ni-Ti rotary instruments.
Group-III - Quantec Ni-Ti rotary instruments.

The prepared teeth were stored in small labeled bottles containing normal saline until scanning electron microscope evaluation.

For scanning electron microscope examination, the teeth were carefully split into two halves with a chisel and hammer. The specimens were then dehydrated, mounted on brass stubs marked with marking pen and gold sputtered in an ion sputtering machine for three minutes to obtain a thickness of 100A° of gold. The specimens were examined under Scanning Electron Microscope (JEOL, Japan model 5309) for assessment of microscopic pattern of magnification and a standardized series of three photomicrographs each were taken for comparison in the apical, middle and coronal thirds of the canal at X200 for debris and X1000 for the smear layer.

Blind evaluation of photomicrographs by two evaluators was conducted to grade the debris and smear layer with a five score index using a rating system proposed by Hulsmann et al (1997) [2] where the criteria for the scoring were as follows:

Scoring of Debris

Score 1- Clean root canal wall, only few small debris particles.
Score 2 - Few small agglomerations of debris
Score 3 - Many agglomerations of debris covering less than 50 % of root canal wall
Score 4 - More than 50% of the root canal covered by debris.
Score 5 - Complete or nearly complete root canal wall covered by debris.

Scoring of Smear layer

Score 1- No smear layer, dentinal tubules open.
Score 2 - Small amounts of smear layer, some dentinal tubules open.
Score 3 - Homogenous smear layer covering the root canal wall, only few dentinal tubules open.

Score 4 - Complete root canal wall covered by homogenous smear layer, no open dentinal tubules.
Score 5 - Heavy, non homogenous smear layer covering complete root canal wall.

Data recorded was statistically analyzed using Mann Whitney 'U' test and Kruskal Wallis test.

RESULTS

The overall results of the study showed that ProTaper hand instruments produced the least amount of smear layer and debris, followed by Quantec series of rotary instruments, while the ProTaper rotary instruments generated the maximum amount of debris and smear layer. Kruskal Wallis test for comparison of debris showed statistically not significant values in the coronal and middle third but very highly significant in the apical third. Mann Whitney 'U' test for intergroup comparison of debris between the groups showed that the ProTaper hand instruments when compared with ProTaper rotary series instruments showed statistically very highly significant results in the apical third, but with Quantec rotary series instruments showed significant results in coronal third only. Amongst the two rotary instruments, ProTaper rotary showed statistically significant differences in the apical third only. Kruskal Wallis test for comparison of smear layer showed statistically significant values in the apical third but not significant in the coronal third and middle third.

Mann Whitney 'U' test for intergroup comparison of smear layer at the apical third showed that the ProTaper hand instruments when compared with Quantec rotary series instruments showed statistically significant results but with ProTaper series of rotary instruments showed very highly significant values in the apical third with no significant values at the coronal and middle third. Amongst the two rotary instruments, ProTaper rotary showed statistically no significant differences at the middle third but highly significant in the coronal and apical third.

Table 1: Mean & Standard deviation values for debris using Kruskal Wallis test

Instrumentation	N	Mean	S.D.	H	P
Coronal Protaper hand	15	1.4667	.51640		
Protaper rotary	15	1.8000	.56061	3.98	.136
Quantec rotary	15	1.3333	.48795		**Not sig**
Middle Protaper hand	15	2.2667	.45774		
Protaper rotary	15	2.6667	.45774	.22	.895
Quantec rotary	15	2.5333	.35187		**Not sig**
Apical Protaper hand	15	2.2667	.69362		
Protaper rotary	15	3.0000	.75593	7.59	.022
Quantec rotary	15	2.8000	.67612		**Sig**

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Table 2: Intergroup comparison of debris between Groups using Mann-Whitney U test

		G I & G II	G II& G III	G I & G III
Coronal	Z P	1.599 0.110	0.733 0.464	2.239 0.025 **Sig**
Middle	Z P	0.000 1.000	0.416 0.677	0.416 0.677
Apical	Z P	2.560 0.01**Sig**	2.064 0.039**Sig**	0.746 0.455

Table 3: Mean & Standard deviation values for smear layer using Kruskal Wallis test

Instrumentation	N	Mean	S.D.	H	P
Coronal Protaper hand	15	1.6667	**.**61721		
Protaper rotary	15	1.9333	.59362	3.98	.136
Quantec rotary	15	2.0667	.45774		**Not sig**
Middle Protaper hand	15	2.2667	**.**70373		
Protaper rotary	15	2.6667	.48795	2.90	.235
Quantec rotary	15	2.5333	.51640		**Not sig**
Apical Protaper hand	15	2.8000	**.**41404		
Protaper rotary	15	3.5333	.63994	13.16	.001
Quantec rotary	15	3.1333	.35187		**VH Sig**

Table 4: Intergroup comparison of smear layer between Groups using Mann-Whitney U test

		G I & G II	G II& G III	G I & G III
Coronal	Z P	1.216 0.224	1.971 0.049**Sig**	0.695 0.487
Middle	Z P	1.639 0.101	1.022 0.307	0.733 0.464
Apical	Z P	3.208 0.001 **VH Sig**	2.207 0.027**Sig**	1.998 0.046 **Sig**

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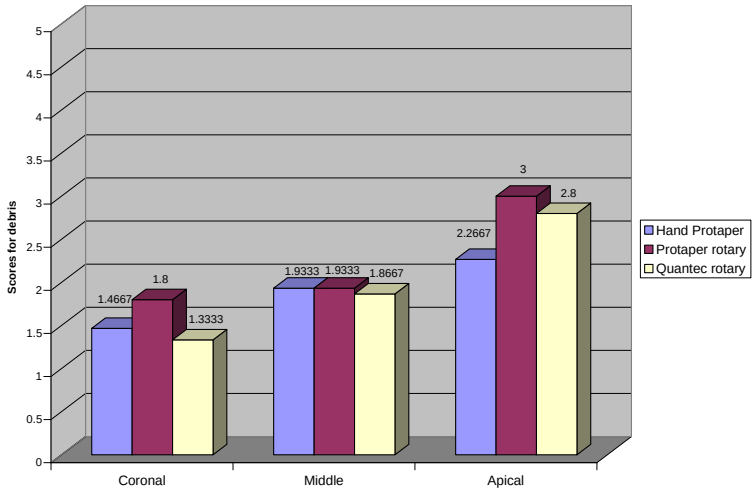
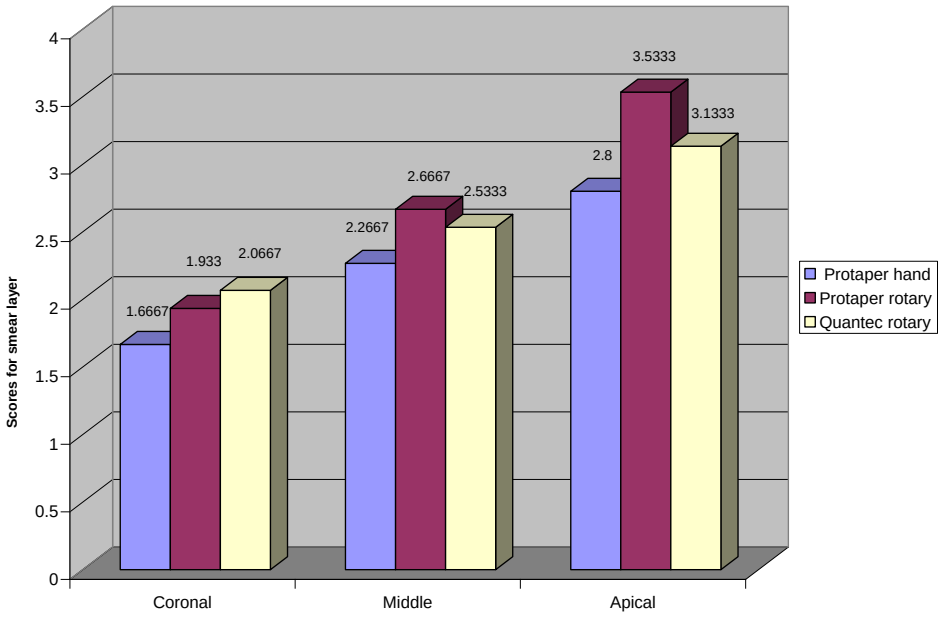


BAR GRAPH SHOWING DEBRIS REMAINING AT THE CORONAL, MIDDLE AND APICAL THIRD



BAR GRAPH SHOWING SMEAR LAYER REMAINING AT THE CORONAL, MIDDLE AND APICAL THIRD

SEM photomicrograph of debris and smear layer following instrumentation with hand ProTaper

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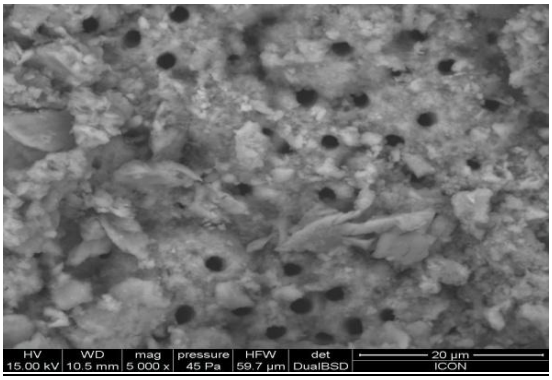
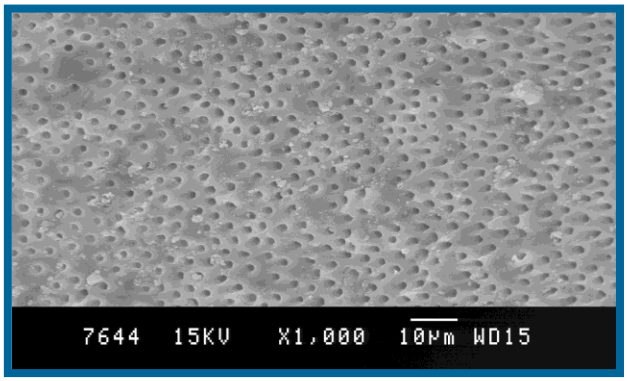
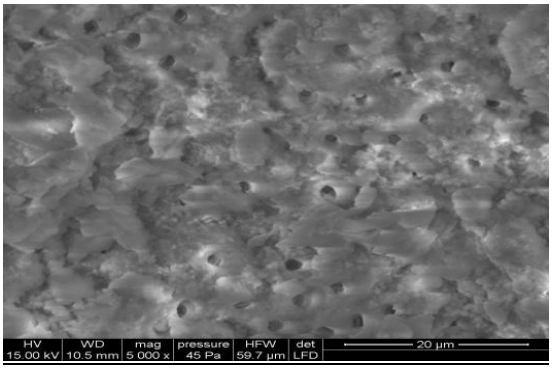
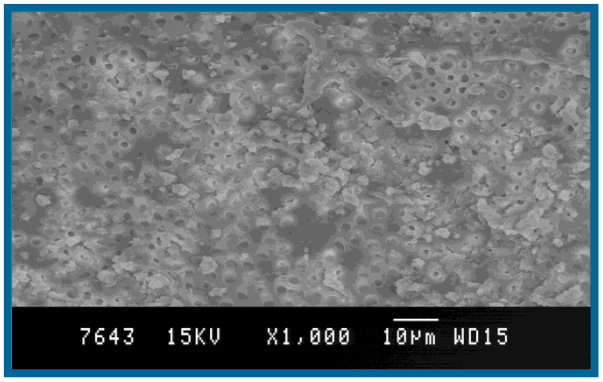


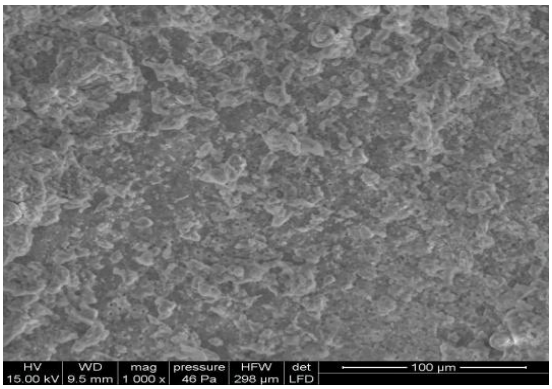


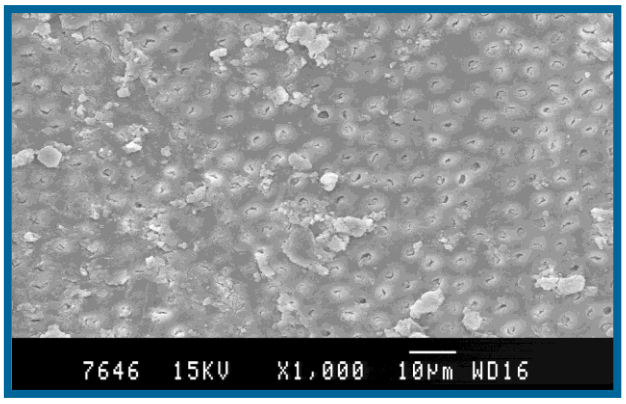
Coronal third





Middle third





Apical third

SEM photomicrograph of debris and smear layer following instrumentation with ProTaper Rotary files

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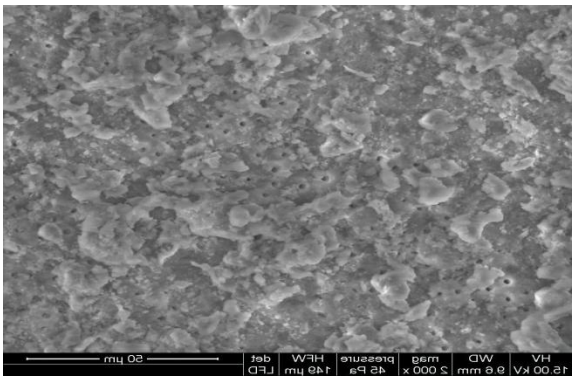

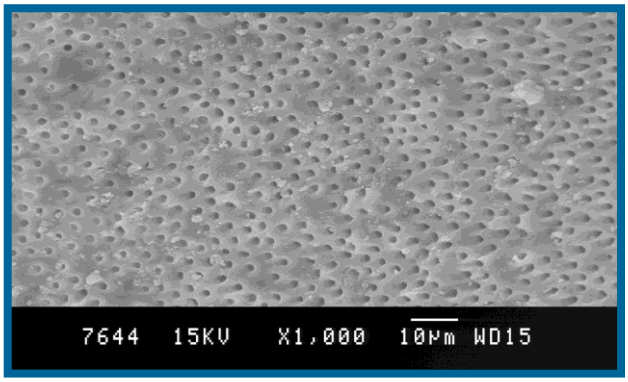

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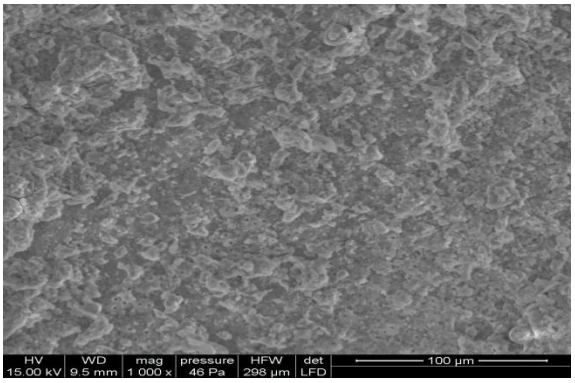

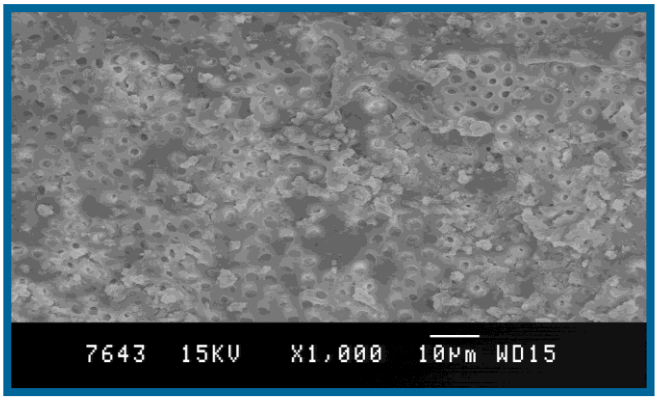

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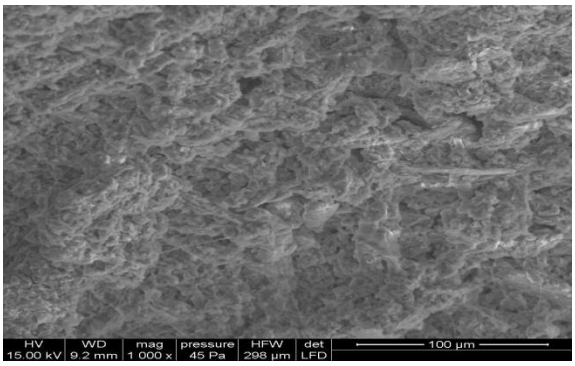

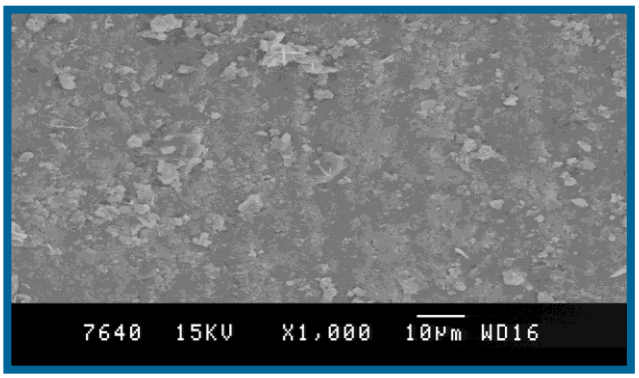

Apical third

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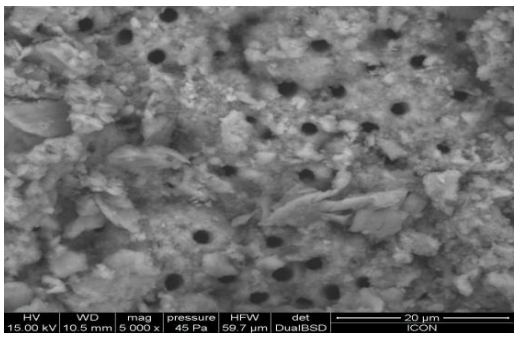
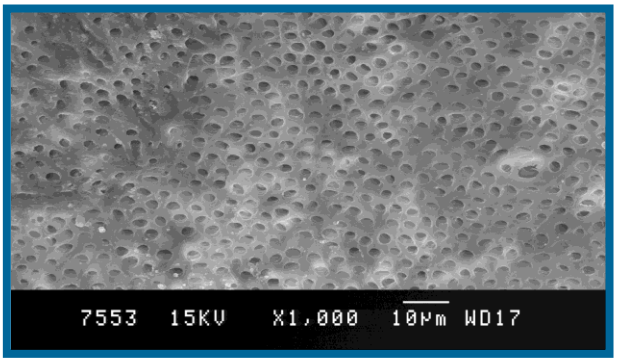
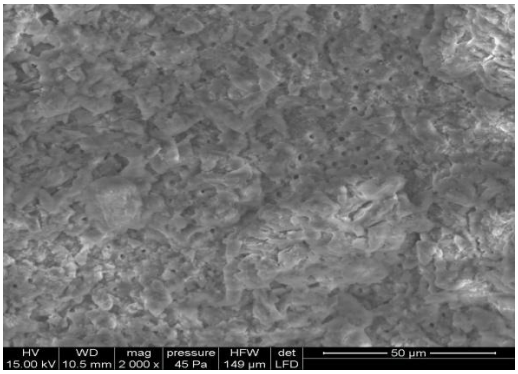
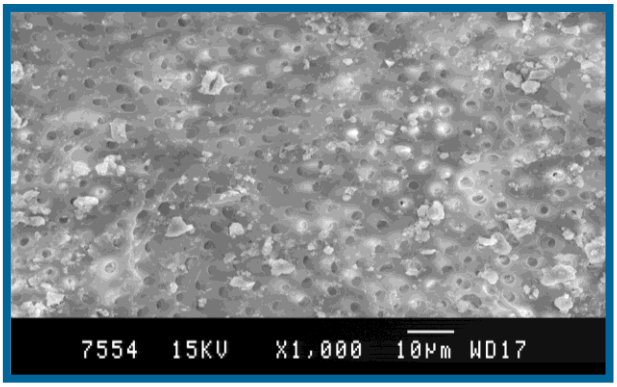
SEM photomicrograph of debris and smear layer following instrumentation with Quantec rotary files



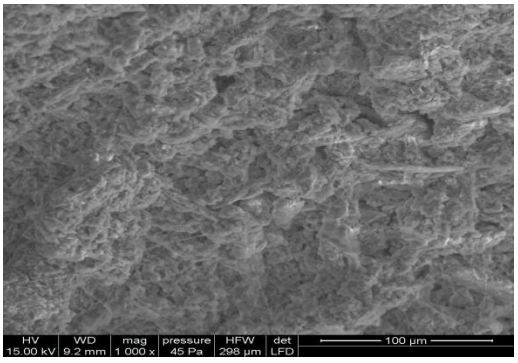


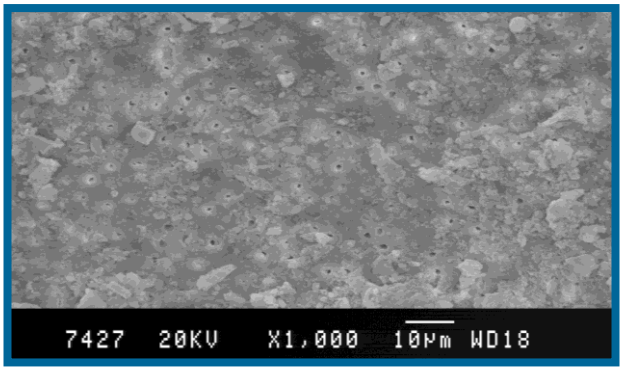
Coronal third





Middle third





Apical third

DISCUSSION

The ability to effectively clean the endodontic space is dependent on two extremely critical steps of instrumentation and irrigation of the root canal.

Endodontic instruments of different designs vary in their debris removal efficacy and smear layer production due to their specific flute design [1]. Irrigation plays a key role in successful debridement and disinfection.

Sodium hypochlorite is an irrigant solution widely used in root canal treatment because of its bactericidal properties and ability to dissolve the organic tissue. However, it is not effective in the removal of inorganic smear layer; therefore, in this study for removal of both organic tissues and inorganic smear layer 3% sodium hypochlorite was used in combination with 15% EDTA which has been proven to be effective in removal of inorganic smear layer. [4, 5]

In this study, efficacy of hand ProTaper instruments, ProTaper rotary and Quantec rotary instruments was compared for removal of debris and smear layer using a scanning electronic microscope for evaluation.

In the present study, Quantec instruments clearly showed superior results in the cervical, middle and apical third compared to ProTaper rotary instruments. The results are similar to ProTaper rotary hand instruments in the middle third. Only a thin smear layer could be detected with many open dentinal tubules in most of the specimens which confirms the superior cleaning ability of Quantec compared to ProTaper rotary instruments. [1, 6] This could be due to the fact that the instrument is designed to collect debris and smear layer material produced during the preparation and carry it out of the canal system which is achieved by continuous rotation and due to the particular instrument profile [7]. The presence of distal notch of constant depth around the distal segment allows the collection and removal of debris and smear layer material. Despite these features, the scores in the apical third of the canal prepared using Quantec instruments were more than the coronal third.

The results by the hand ProTaper instruments were clearly superior to rotary instruments in the coronal, middle and apical third. ProTaper hand instruments have a wide range of tapers and designs. The instrument has a balanced pitch and a helical angle that optimizes the cutting action and aids in debris removal. Secondly, the instrument tip has a partially active tip that is designed to aid smooth advancement of instrument apically, ability to debride the tissue in the apical portion of the canal by creating space for the movement of the irrigants and chelating agents. This is possible particularly by using the S1 and S2 instruments coronally and the F1, F2 and F3 apically. In this study, the amount of debris and smear layer produced by hand ProTaper was relatively less compared to both the rotary instruments. This could be due to the increased centrifugal forces resulting from movement and proximity of instrument to the dentinal wall which forms a thicker and more resistant smear layer. [8] Thus, the production of smear layer and debris in rotary preparation is greater in volume than that produced by hand instruments [9].

The results of the apical third in the present study as with those of the other studies showed how difficult it is to remove debris and smear layer from the apical third [10]. On the other hand, using EDTA for 30 seconds, reported good cleaning of the apical third, although some smear plugs were noticed in some of the specimens [11]. It has been reported that, the reduced dimension of root canal at the apical third frequently caused entrapment of air bubbles and thus prevented total cleaning by the irrigant [11]. However, in the present study,

the method of shaping and instrumentation was analyzed with the irrigant used, time of irrigation and technique as a constant.

In the present study, hand instruments showed minimal amount of smear layer and debris production. Amongst the rotary, the Quantec series showed better results than Pro-Taper rotary series. All type of instrumentation showed some amount of debris and smear layer with inefficiency of cleaning at the apical third.

CONCLUSION

The present in vitro study evaluated the amount of debris and smear layer remaining following the use of ProTaper hand, ProTaper rotary instruments and Quantec rotary instruments in combination with 3% sodium hypochlorite and 15% EDTA.

Within the limitations of this study, the following conclusions were drawn:

Neither hand nor rotary preparation technique achieved total root canal debridement. Both hand and rotary instruments produced debris and smear layer

Pro-Taper hand instruments produced least amount of debris and smear layer.

When comparing hand ProTaper, ProTaper rotary instruments and Quantec rotary instruments, ProTaper rotary instruments showed maximum amount of debris and smear layer followed by the Quantec rotary instruments.

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