A scanning electron microscopic study of 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 smear layer in the root canal following the use of Ni-Ti hand ProTaper, HERO shaper and Twisted rotary instruments. Fifteen freshly extracted single rooted human mandibular premolar teeth were selected. Crowns of all teeth were cut off at the cemento-enamel junction with a carborundum disc. The roots were then randomly divided into three groups of 5 samples each. The working length of all teeth was established by the insertion of an endodontic instrument into the canal until its tip is visible at the apical foramen and then subtracted by 0.5 mm. A sequential crown down technique was carried out in all the three groups as follows: Group-I- Specimens in this group were instrumented with ProTaper Ni-Ti hand instruments. Group-II- Specimens were instrumented with HERO shapers. Group-III - The specimens in this group were instrumented with Twisted rotary instruments. Irrigation was done with 3% NaOCl and 15% EDTA in all the three groups. Teeth were carefully split with hammer and chisel and stored in small labeled bottles containing normal saline until SEM evaluation. Results showed that when comparing ProTaper files, Twisted rotary instruments and HERO shaper instruments, HERO shaper series of rotary instruments showed maximum amount of smear layer followed by the Twisted rotary instruments. Hand instruments produced least amount of smear layer.

Key words: HERO Shaper, Ni-Ti, ProTaper, root canal preparation, SEM, smear layer, twisted rotary instruments

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INTRODUCTION

Thorough debridement of the root canal system is considered one of the most important steps in root canal treatment. Studies have shown that the current methods of cleaning and shaping root canals produce a smear layer that covers the instrumented walls. Thorough cleaning removes micro-organisms and permits better adaptation of filling material and enhances the action of intra canal medicaments

All endodontic instruments create dentinal debris and smear layer as a consequence of their action on root canal walls. Hand instrumentation has remained a standard for more than five decades and continues to be a standard method of pulp space instrumentation. However, more recently several investigators have demonstrated that rotary systems using Ni-Ti instruments led to good results in the instrumentation of pulp spaces.

Ni-Ti instruments represent a relatively new approach to the rapid preparation of canals with standardized taper. The amount, the thickness and type of smear layer produced by newer Ni-Ti instruments must be assessed.

Recently, new rotary Ni-Ti instruments with different configuration and design have been marketed as Twisted rotary instruments SybronEndo (Orange, CA), and HERO shapers (Micro-Mega, Besençon France).

EDTA in combination with NaOCl is an excellent combination of irrigant to remove all tissue, necrotic debris, infected pre dentin and dentin, smear layer as well as softened dentin to a great extent, for efficient final cleaning and shaping of the pulp space.

The purpose of this study was to evaluate under SEM, the type of smear layer produced by the newer Twisted rotary

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instruments in comparison to the time tested endodontic hand instruments.

MATERIALS AND METHODS

A comparative *in vitro* study to evaluate the smear layer in the root canal following the use of ProTaper hand instruments, Twisted rotary instruments and HERO shapers instruments was undertaken in the Department of Conservative Dentistry and Endodontics, Dr. D.Y. Patil Institute Of Dental College And Hospital, Pimpri, Pune.

Fifteen freshly extracted, intact, non-carious and unrestored single rooted and single canaled human mandibular premolars collected, stored, disinfected and handled as per the recommendations and guidelines laid down by OSHA and CDC. All the collected teeth were cleared of blood, calculus and surface deposits and stored in isotonic saline. The selected specimens were utilized for study within one month of extraction and storage. Teeth were randomly distributed among the groups.

The extracted teeth stored in normal saline were retrieved. Conventional endodontic access cavities were prepared in a high speed handpiece. To determine the working length a size 10 K-file was inserted until it reached the apical foramen and 0.5 mm was subtracted from its length. A small amount of wax was placed on the tip of each root to prevent irrigating solutions from passing through the apical foramen.

CANAL INSTRUMENTATION

Crowns of all teeth were cut off at the cemento-enamel junction with a carborundum disc. The roots were then randomly divided into 3 groups of five samples each.

A sequential CROWN DOWN TECHNIQUE was carried out in all the three groups.

Group-I

Specimens in this group were instrumented with ProTaper Ni-Ti hand instruments. CROWN DOWN SEQUENCE- S-1, S-2, F-1, F2 and F-3 was followed.

Group-II

Specimens were instrumented with HERO shaper rotary instruments in a high torque, low speed hand piece with speed range between 300-600 rpm. Coronal to apical instrumentation technique- .06T size 20, .04T size 25, and .02T size 25 was followed according to the instructions.

Group-III

The specimens in this group were instrumented with Twisted series of rotary instruments in low speed hand piece with speed range between 300-350 rpm. Coronal to apical instrumentation technique- size 25, 0.06 taper was followed according to the manufacturer's instructions.

Irrigation was carried out with 10 ml of 3% NaOCl and 9.6 gms of 15% EDTA was used as chelating agent in all the 3 groups.

SEM EXAMINATION

To facilitate fracture into 2 halves for SEM examination, all roots were grooved longitudinally on the external surfaces with a carborundum disk avoiding penetration of root canals. Teeth were carefully split with hammer and chisel and stored in small labeled bottles containing normal saline until SEM evaluation.

The specimens were then dehydrated, mounted on brass stubs. The stubs were marked with marking pen and gold sputtered for three minutes for a thickness of 100A° of gold in an ion sputtering machine. The specimens were examined under SEM (JEOL, Japan model 5309) for assessment of microscopic pattern of magnification X1000 for smear layer. A standardized series of 3 photomicrographs were taken for each pulp space (one in the apical third, one in the middle third and one in the coronal third) for comparative purposes.

Blind Evaluation of the photomicrographs was done by 2 evaluators to grade the smear layer with a 5 score index for each using reference photographs. Photomicrographs at X1000 (for the smear layer) were taken in the apical, middle and coronal thirds of the canal. Each field was graded from score 1 to score 5 according to the scoring system and the mean value was calculated for each region of each half of the root. The rating system was used as proposed by Hulsmann *et al*[1] and the criteria for the scoring were as follows

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

Results were statistically analyzed using Kruskal Wallis test [Table 1] and Mann-Whitney 'U' test [Tables 2-4]. Results of the study showed that ProTaper hand instruments produced the

Table 1: Mean and Standard deviation values for smear layer using Kruskal Wallis test

Method of instrumentation	N	Mean	S.D.	H	P
Coronal ProTaper hand	5	1.6667	.61721		
HERO shaper	5	1.9333	.59362	3.98	.136 ns
Twisted rotary	5	2.0667	.45774		
Middle ProTaper hand	5	2.2667	.70373		
HERO shaper	5	2.6667	.48795	2.90	235 ns
Twisted rotary	5	2.5333	.51640		
Apical ProTaper hand	5	2.8000	.41404		
HERO shaper	5	3.5333	.63994	13.16	.001 vhs
Twisted rotary	5	3.1333	.35187		

(NS-not significant, VHS=very highly significant)

Table 2: Intergroup comparison between Group I and Group II using Mann-Whitney U test

Coronal	Z	1.216
	P	0.224
Middle	Z	1.639
	P	0.101
Apical	Z	3.208
	P	0.001 vhs

(NS-not significant, VHS=very highly significant)

Table 3: Intergroup comparison between Group II and Group III using Mann-Whitney U test

Coronal	Z	1.971
	P	0.049 sig
Middle	Z	1.022
	P	0.307
Apical	Z	2.207
	P	0.027 sig

(NS-not significant, VHS=very highly significant)

Table 4: Intergroup comparison between Group I and Group III using Mann-Whitney U test

Coronal	Z	0.695
	P	0.487
Middle	Z	0.733
	P	0.464
Apical	Z	1.998
	P	0.046 sig

least amount of smear layer and debris, followed by Twisted rotary instruments as shown in Figures 1 and 2. HERO shaper rotary instruments generated the maximum amount of smear layer as shown in Figure 3.

DISCUSSION

The ability to clean effectively the endodontic space is dependent on instrumentation and irrigation which is the most important step in root canal treatment. Endodontic instruments may, in themselves create smear layer which plays a key role in successful debridement and disinfection.

Due to the bacterial content of the smear layer, any apical extrusion of the smear layer during instrumentation or obturation can defeat one of the goals of the endodontic therapy; the return to and maintenance of an inflammation free state in the periapical area. Endodontic sealers act as glue to ensure a good adaptation of gutta percha to the dentin walls. If the smear layer is not removed, the gutta percha may occasionally be glued to the dentin in the smear layer, as well as to the exposed parts of the canal wall. Not being firmly attached to the dentin, the smear layer may laminate off the canal wall and create a false seal, voids in the filling and an expected environment for micro leakage.[1]

NaOCl is an irrigant solution widely used in root canal treatment because of its bactericidal properties and ability to dissolve the organic tissue. A combination of NaOCl and EDTA has been reported to be suitable for removing both organic tissues and inorganic smear layer.[2]

In this study, 9.6gms of EDTA paste15% (Glyde) was used which has been proved to be effective in removing inorganic smear layer. [3,4]

Ni-Ti instruments have been developed in an attempt to overcome the limitations imposed by stainless steel alloys. Ni-Ti instruments are 2 or 3 times more flexible than stainless steel files, exceed standard specifications for stiffness, angular deflection, and maximum torque to failure and their fracture resistance is unaffected by prolonged exposure to sodium hypochlorite.[5] Several studies have confirmed the ability of rotary Ni-Ti instruments to maintain original root canal curvature even in severely curved canals.[3,4,6] In the present study, efficacy of hand ProTaper instruments, HERO shaper and Twisted rotary instruments have been evaluated for the removal of smear layer using SEM for evaluation.

In the present study, Twisted rotary instruments clearly showed superior results in the cervical, middle and apical third compared to HERO shaper rotary instruments and the results are similar to ProTaper hand instruments in the middle third [Tables 2-4]. Only a thin smear layer could be detected with many open dentinal tubules in most of the specimens in group III, which confirms the superior cleaning ability of Twisted compared to HERO shaper rotary instruments.[7,8] This could be due to instrument designed to collect debris and smear layer material produced during the preparation and carrying it out of the canal system. This is achieved by continuous rotation and the particular instrument profile.[9] Twisted file instruments are non-landed with positive rake angles. It is made by twisting a file blank in combination with an R phase heat treatment and a deoxidation surface treatment, which increases the surface hardness and sharpness of the cutting flutes.[10] It is triangular in cross section and has got superior flexibility due to the smallest cross sectional area resulting in best fatigue resistance.[10] Despite these features, the scores in the apical third of the

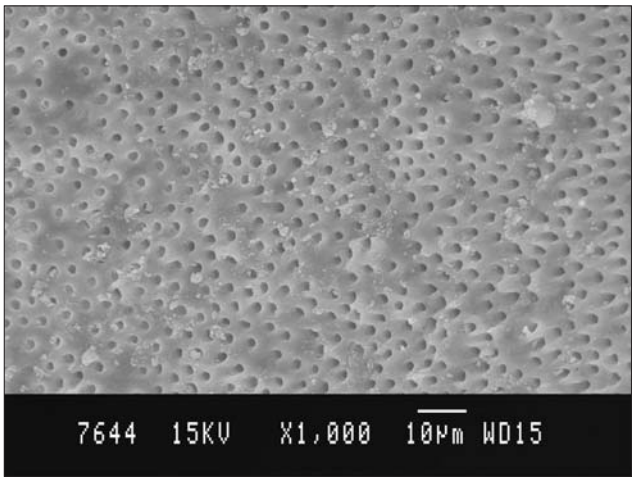

Figure 1a: SEM picture of smear layer remaining following the use of ProTaper hand file a) coronal third

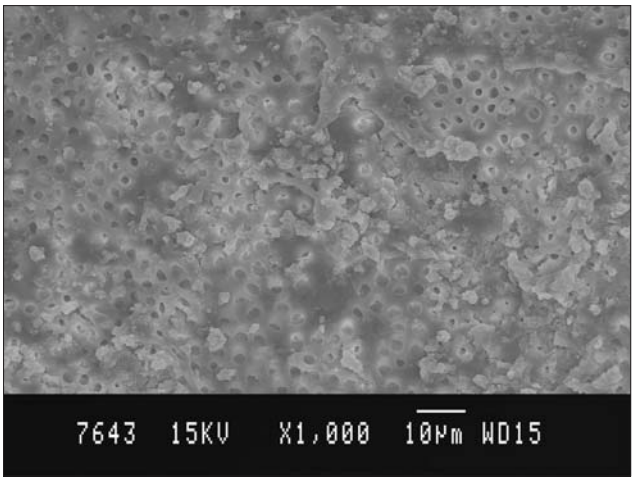

Figure 1b: SEM picture of smear layer remaining following the use of ProTaper hand file b) middle third

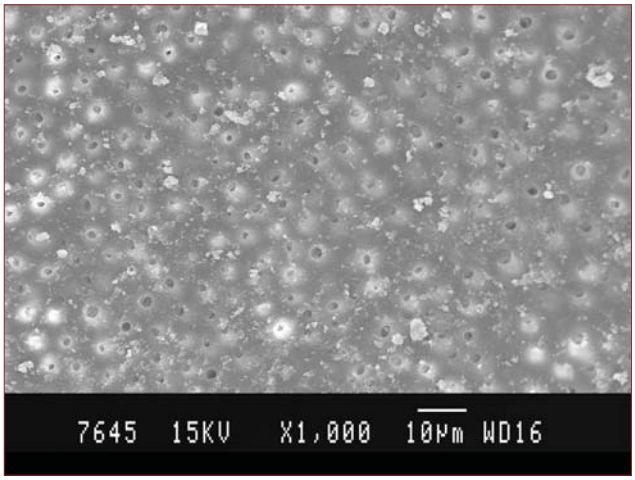

Figure 1c: SEM picture of smear layer remaining following the use of ProTaper hand file c) apical third

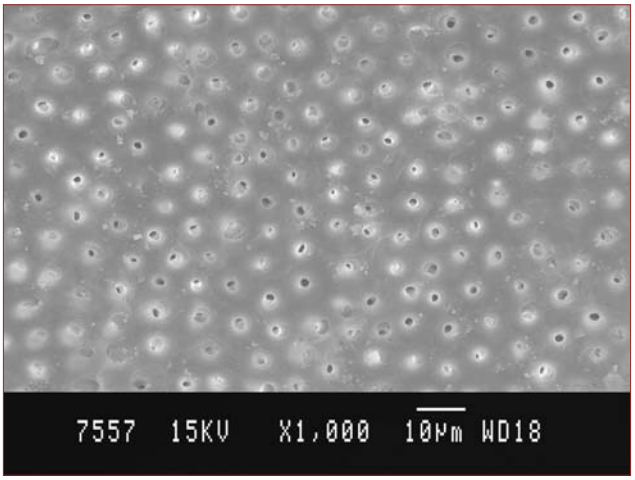

Figure 2a: SEM picture of smear layer remaining following the use of Twisted files a) coronal third

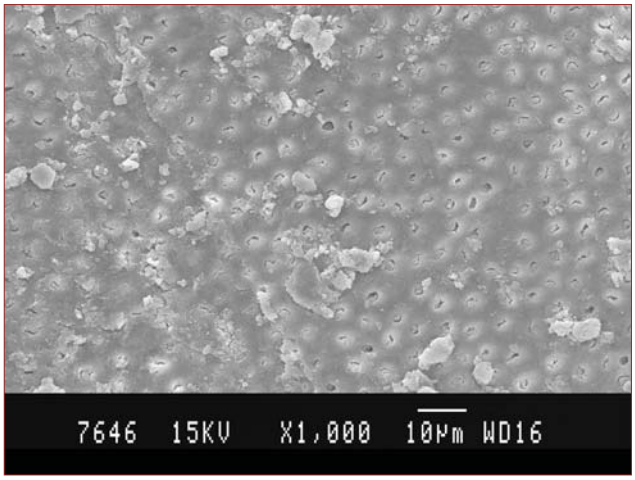

Figure 2b: SEM picture of smear layer remaining following the use of Twisted files b) middle third

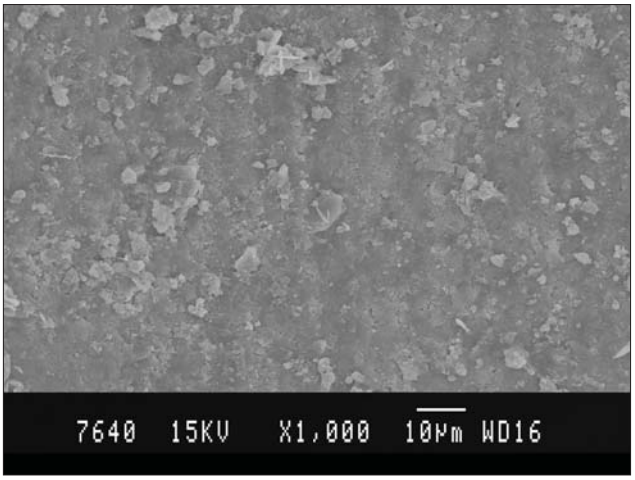

Figure 2c: SEM picture of smear layer remaining following the use of Twisted files c) apical third

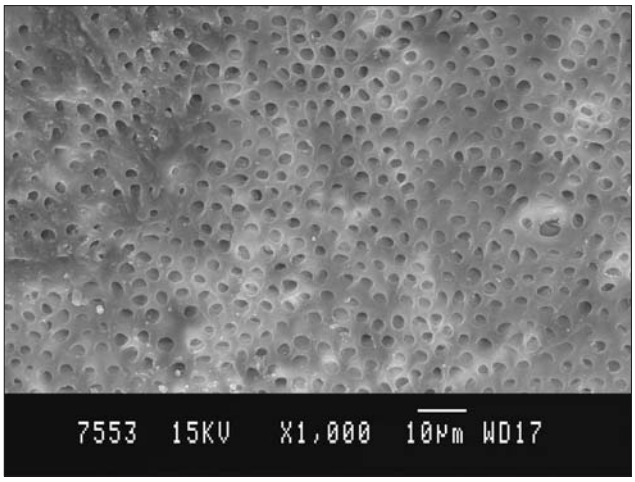

Figure 3a: SEM picture of smear layer remaining following the use of HERO shapers a) coronal third

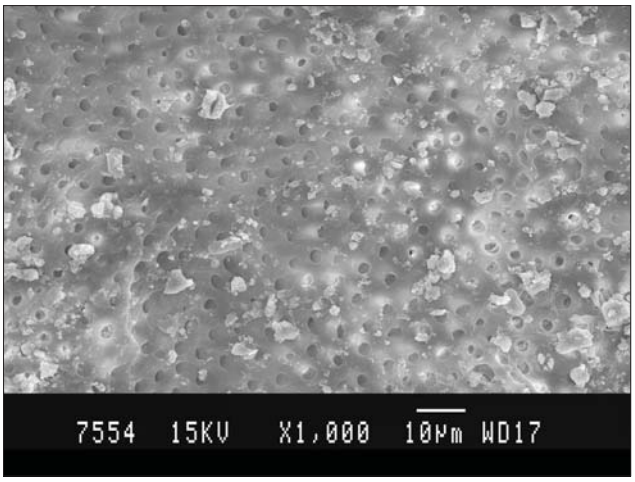

Figure 3b: SEM picture of smear layer remaining following the use of HERO shapers b) middle third

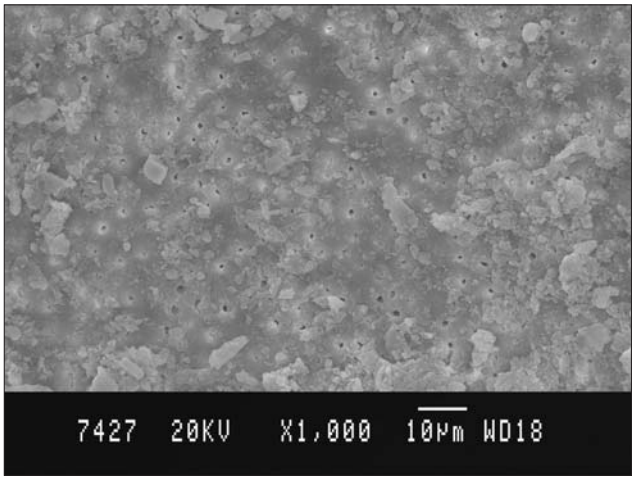

Figure 3c: SEM picture of smear layer remaining following the use of HERO shapers c) apical third

canal prepared using Twisted rotary instruments were more than the coronal third.

The result of the present study also clearly states that the minimum smear layer were produced by the ProTaper hand instruments, since the technique and type of irrigating solution was kept standard for all 3 instrumentation techniques. The results 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 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 is possible particularly by S1 and S2 instruments coronally and F1, F2 and F3 apically.

The varying helical pitch and length of the cutting portion of the HERO shaper files provide them with an excellent combination of efficiency and flexibility. When cutting with TF, chips of dentin usually are found in the wider flutes nearer the handpiece end. In other words, while the instrument can cut near its tip end (even though TF has a non cutting pilot tip) i.e. the 3-4 mms at the tip of the instrument does not generally have debris on it. This demonstrates that TF cuts away from the tip. As a result, aside from the fracture resistance provided by the using R phase technology and twisting, the cutting mechanism present clinically reinforces safety.[11] The Twisted File is the first file that can be used Crown Down and/or as a Single File instrument in many cases and do so with unparalleled safety and cutting efficiency.[11]

The amount of smear layer produced by ProTaper has been less compared to rotary which can be due to increased centrifugal forces resulting from movement and proximity of instrument to the dentinal wall forming a thicker and more resistant smear layer.[12] Hence, the production of smear layer in rotary preparation is greater in volume than that produced by hand filing.

It has been shown that cleaning can be significantly improved once the shaping procedure has been completed. In the present study, Crown down technique in cleaning and shaping has been advocated.

The results of the apical third in the present study as with those of the other studies showed how difficult it is to remove smear layer from the apical third.[13] It was reported that, the reduced dimension of root canal at the apical third frequently caused entrapment of air bubbles and prevented total wetting with the irrigant.[14] On the other hand, using EDTA for 30 seconds, reported good cleaning of the apical third, although, they did notice some smear plugs in some

of the specimens.[14] However, in the present study, the method of shaping and instrumentation was analyzed with the type of irrigant used, time of irrigation and technique as a constant.

In the present study, hand instruments showed minimal amount of debris production. In the rotary, Twisted series showed better results than rotary HERO shaper series. All type of instrumentation showed some amount of smear layer with inefficiency of cleaning at the apical third. However, the irrigating solution (antibacterial solution) and chelating agent used in this study was limited. Additional irrigation with antibacterial solution has been recommended by several authors to remove debris, as well as smear layer. However, none of the instrumentation technique so far has shown a smear free surface in the apical third of the canal. Further *in vitro* and *in vivo* investigation is required to evaluate the efficacy of these instruments in the removal of smear layer.

CONCLUSION

The present *in vitro* study evaluated the amount of smear layer remaining following the use of ProTaper hand, HERO shaper instruments and Twisted rotary instruments in combination with 3% sodium hypochlorite and 15% EDTA (Glyde)

Under the conclusion of this study, the following conclusions were drawn:

i Neither hand nor rotary preparation technique achieved total root canal debridement, both hand and rotary instruments produced smear layers.
ii ProTaper hand instruments produced least amount of smear layer.

When comparing ProTaper hand, HERO shaper rotary instruments and Twisted rotary instruments, HERO shaper series of rotary instruments showed maximum amount of smear layer followed by the Twisted series of rotary instruments.

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