

## Smear layer and debris removal using manual Ni-Ti files compared with rotary Protaper Ni-Ti files - An In-Vitro SEM study

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### Abstract:

**Background:** Predictable successful endodontic therapy depends on correct diagnosis, effective cleaning, shaping and disinfection of the root canals and adequate obturation. Irrigation serves as a flush to remove debris, tissue solvent and lubricant from the canal irregularities; however these irregularities can restrict the complete debridement of root canal by mechanical instrumentation. Various types of hand and rotary instruments are used for the preparation of the root canal system to obtain debris free canals. The purpose of this study was to evaluate the amount of smear layer and debris removal on canal walls following the using of manual Nickel-Titanium (NiTi) files compared with rotary ProTaperNiTi files using a Scanning Electron Microscope in two individual groups.

**Materials & Methods:** A comparative study consisting of 50 subjects randomized into two groups - 25 subjects in Group A (manual) and 25 subjects in Group B (rotary) was undertaken to investigate and compare the effects of smear layer and debris between manual and rotary NiTi instruments. Chi square test was used to find the significance of smear layer and debris removal in the coronal, middle and apical between Group A and Group B.

**Results:** Both systems of Rotary ProTaperNiTi and manual NiTi files used in the present study, did not create completely clean root canals. Manual NiTi files produced significantly less

smear layer and debris compared to Rotary ProTaperNiTi instruments. Rotary instruments were less time consuming when compared to manual instruments. Instrument separation was not found to be significant with both the groups.

**Conclusions:** Both systems of Rotary ProTaperNiTi and manual NiTi files used did not produce completely clean root canals. Manual NiTi files produced significantly less smear layer and debris compared to Rotary protaper instruments.

**Key Words:** Debridement, manual NiTi files, ProTaperNiTi, smear layer

### Introduction

Predictable successful endodontic therapy depends on correct diagnosis, effective cleaning, shaping and disinfection of the root canals, and on adequate obturation.<sup>1</sup>

Primary objective of canal preparation include removal of organic substrate from the canal system by chemo-mechanical preparation and the three dimensional shaping of the root canal system into a continuously tapering preparation while maintaining the original outline and form of the canal. (Schelder 1974)<sup>2</sup>

After gaining straight line access for root canal therapy, through cleaning and shaping is important for the success of root canal treatment. Root canal preparation includes shaping and cleaning, shaping facilitates cleaning by removing the restrictive dentin which provides space for root canal which allows extra volume of irrigants to flow in the canal which will serve to eliminate pulpal tissue, bacteria and endotoxins.

One should have thorough knowledge about the anatomy of root canal to be treated prior to the instrumentation. Irregularities in the root canal system can restrict the complete debridement of root canal by mechanical instrumentation. Irrigation serves as a flush to remove debris, tissue solvent and lubricant.

Since inadequate debridement of the root canal system is one of the causative factor for endodontic flare up, it is important to be precise on cleaning of the root canal to reach the goal of successful treatment. Various types of

hand and rotary instruments are used for the preparation of root canal system to obtain debris free root canal.

The basic design of root canal instruments has changed very little over the years, apart from the minor modifications such as new materials, improved cutting edges and greater flexibility. One of the many innovations in root canal instruments is the use of nickel titanium for file manufacture, which have two to three times more elastic flexibility than and appear to be more fracture resistant compound to stainless steel files (Knowles et al 1996).<sup>3</sup>

During last decade several new, Ni-Ti instruments for manual root canal preparation, as well as for use in rotary endodontic hand pieces have been developed, in order to facilitate the difficult and time consuming process of cleaning and shaping the root canal system and to improve the final quality of root canal preparation.<sup>4</sup>

Thorough debridement of the root canal system is considered one of the most important steps in root canal treatment. The main objective of the biomechanical instrumentation is the total elimination of the infected pulp tissue from the root canal (Smith et al 1993). In addition pulpal remnant debris and smear layer produced by instrumentation of the root canal walls must be removed (Cergneux et al 1987, Gettleman et al 1991).<sup>5</sup>

According to American Association of Endodontists (2000), smear layer is defined as a surface film of debris retained on dentin or other surface, after instrumentation with either rotary instruments or endodontic files. It consists of dentin particles' remnants of vital or necrotic pulp tissue, bacterial components and retained irrigants.<sup>6</sup>

The irrigant solution should have disinfectant and organic debris dissolving properties while not irritating the periradicular tissues. During root canal treatment immediately after pulpectomy, a sterile irrigation solution without these properties may alternatively be used. The

solution may also be delivered by ultrasonic, sonic and mechanical reciprocating instruments equipped with irrigating systems.

Prolonged tissue / Chemical contacts unfortunately in curved, narrow root canal and in areas inaccessible to routine instrumentation. The action of the NaOCl is often limited because tissue contact is minimal. NaOCl cannot remove the endodontic smear layer, which is always formed on the instrumented canal walls. The association of NaOCl and EDTA solution has been advocated to effectively remove soft tissue remnants as well as the inorganic / organic smear layer.<sup>7</sup>

Numerous studies have been reported on the relative effectiveness of different instrumentation techniques based on a variety of ways of evaluating canal debridement outcomes of instrumentation differ according to method of canal preparation and evaluation. Each method showing advantages and disadvantages.<sup>8</sup>

Introduction of SEM has proved to be valuable method for assessment of the ability of the endodontic procedures to remove debris from root canals thus enabling comparison of instruments and techniques.

The purpose of this study is to evaluate the amount of smear layer and debris on canal walls following using of manual Ni - Ti files compared with Rotary protaper using a scanning electron microscope in two separate individual groups.

### Materials and Methods

A total of 50 maxillary permanent central incisors extracted for various reasons were collected from the department of oral and maxillofacial surgery. Teeth were cleaned ultrasonically and refrigerated at 4-degree Celsius before instrumentation to facilitate their fracture for scanning electron microscope examination. Access opening was done using an Endo access bur (Dentsply, mullifer), working length determination was done 1mm short of the



Figure 1: Armamentarium.



Figure 2: Collected specimens.



Figure 3: Gold and palladium coated specimens.

apex by placing a 10-size K file (Dentsply, mallifer) at the apical foramen. The teeth were divided into two groups with 25 teeth in each group. Figure 1 shows the armamentarium & Figure 2 shows specimens of teeth collected.

**Irrigation**

During the preparation in both groups, Irrigation regimen was standardized with 3% Sodium Hypochlorite (NaOCl)

and 17% EDTA one after the other and quantity of the irrigation solutions used for each canal was 4ml of 3% Sodium Hypochlorite and 2ml of 17% EDTA. A No.25 gauge needle syringe was used to deliver the irrigant into each canal. After preparation, all the root canals were cleaned with 3% Sodium Hypochlorite and dried with absorbent paper points. Crown portion was removed with the wheel diamond disc and the roots were split longitudinally into two halves using a chisel and mallet and then prepared for viewing under a Scanning Electron Microscope. Figure 3 shows gold and palladium coated split specimens.

**Instrumentation Procedure:**

**Group A: Manual instrumentation** was performed with NiTi files using reaming motion. Starting with 10 sized K flexofile (Dentsply, maillfer), the canal preparation progressed in a step down fashion in 1mm increment in each smaller file size until the working length was reached. The canal was then enlarged sequentially with the larger

Table 1: Comparison of Smear layer between Group A and Group B.

Smear Layer Scoring	Coronal		Middle		Apical	
	Group A (n=25)	Group B (n=25)	Group A (n=25)	Group B (n=25)	Group A (n=25)	Group B (n=25)
1. No Smear Layer, dentinal tubuli open.	18 (72.0)	1 (4.0)	14 (56.0)	3 (12.0)	9 (36.0)	4 (16.0)
2. Small amount of Smear Layer, some dentinal tubuli open.	5 (20.0)	12 (48.0)	8 (32.0)	11 (44.0)	8 (32.0)	7 (28.0)
3. Homogeneous Smear Layer covering root canal wall, few dentinal tubuli open.	2 (8.0)	4 (16.0)	1 (4.0)	7 (28.0)	7 (28.0)	8 (32.0)
4. Complete root wall covered by a homogeneous smear layer, no open dentinal tubuli.	-	8 (32.0)	2 (8.0)	3 (12.0)	1 (4.0)	5 (20.0)
5. Heavy, non-homogeneous smear layer covering the complete root canal.	-	-	-	1 (4.0)	-	1 (4.0)
Significance	P<0.001		P=0.005		0.131	

Table 2: Comparison of Debris between Group A and Group B.

Debris Scoring	Coronal		Middle		Apical	
	Group A (n=25)	Group B (n=25)	Group A (n=25)	Group B (n=25)	Group A (n=25)	Group B (n=25)
1. Clear root canal wall, only few small debris particles	16 (64.0)	10 (40.0)	16 (64.0)	10 (40.0)	15 (60.0)	10 (40.0)
2. Few small agglomerations of debris	6 (24.0)	15 (60.0)	7 (28.0)	14 (56.0)	8 (32.0)	13 (52.0)
3. Many agglomerations of debris covering less than 50% of the root canal wall	3 (12.0)	-	1 (4.0)	1 (4.0)	1 (4.0)	2 (4.0)
4. More than 50% of the root canal wall covered	-	-	1 (4.0)	-	-	-
5. Complete or nearly complete root canal wall debris	-	-	-	-	1 (4.0)	-
Significance	0.016		0.132		0.334	

Ni-Ti files upto 40 size. Copious irrigation was done with 3% NaOCl and 17% EDTA throughout the preparation and patency was maintained in all the canals recapitulating by using a 10 size K file.

**Group B: ProTaper (Rotary):** The protaper instruments were used according to manufacturer instructions. The canal and the chamber were flooded with 3% Sodium Hypochlorite before beginning shaping with shaper S1 file (ProTaper, Dentsply, mallifer). The standard root canal ProTaper procedure was then followed to prepare the root canals till finishing file F4 (ProTaper, Dentsply, mallifer). Each of the samples in Group A and Group B were divided into 3 areas from the coronal, middle and the apical portion and examined under scanning microscope at X 1000 magnification for the evaluation of debris and smear layer. The scoring was given separately for debris and smear layer as follows:

**For Debris:** (Dentin chips, pulp remnants, and particles loosely attached to the canal wall)

- Score 1: Clean canal wall, very little debris particles.
- Score 2: Few coglomerations of debris
- Score 3: Many coglomerations, < 50% of the canal wall covered by debris
- Score 4 : >50% of the canal wall covered with debris.

Score 5: Complete or nearly complete covering of the canal wall by debris

**For Smear Layer**

- Score 1: No smear layer, orifice of Dentinal tubuli patent.
- Score 2: Small amounts of smear layer, some dentinal tubuli patent open.
- Score 3: Homogenous smear layer along almost the entire canal wall, only very few dentinal tubuli open.
- Score 4: The Entire root canal wall is covered with homogenous smear layer, no open dentinal tubuli.
- Score 5: A thick homogenous smear layer covering the entire root canal wall.

The specimens were examined under scanning electron microscope for the results.

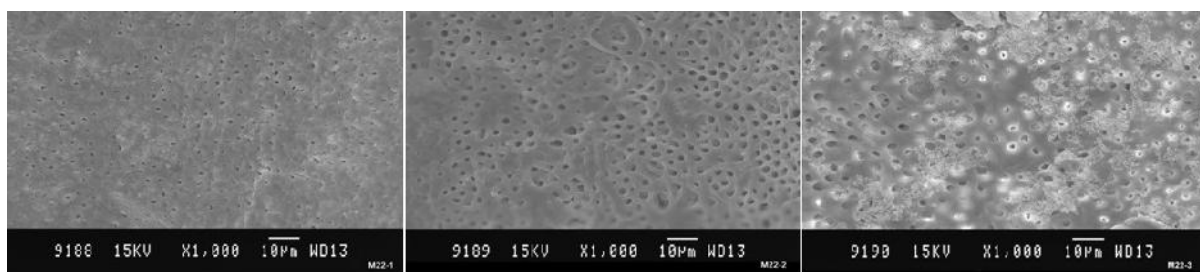
Chi square test was used to find the significance of percentage of coronal, middle and apical between Group A and Group B for the Smear layer and Debris. The Statistical software SPSS 11.0 and Systat 8.0 were used for the analysis of the data and Microsoft word and Excel have been used to generate graphs and tables.

**Results**

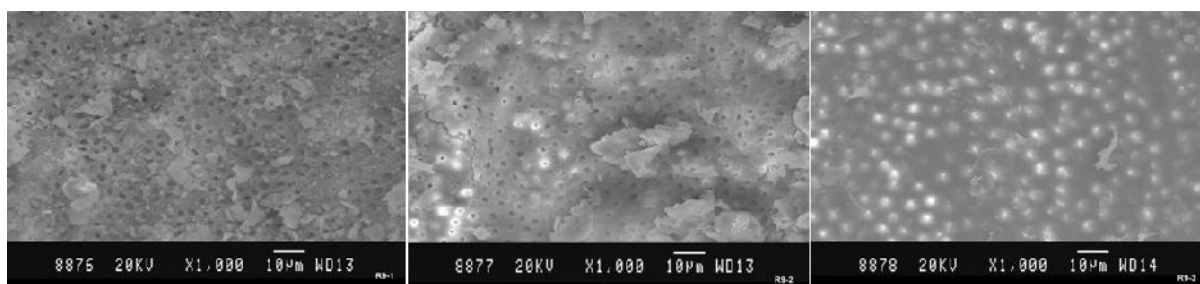
**Scanning Electron Microscopic Analysis**

**Group A: MANUAL INSTRUMENTATION**

**Group B: ROTARY INSTRUMENTATION**



**Figure 4:** Group A: MANUAL INSTRUMENTATION  
 - SEM view of CORONAL THIRD of specimen from Group A.  
 - SEM view of MIDDLE THIRD of specimen from Group A.  
 - SEM view of APICAL THIRD of specimen from Group A.



**Figure 5:** Group B: ROTARY INSTRUMENTATION  
 - SEM view of CORONAL THIRD of specimen from Group B.  
 - SEM view of MIDDLE THIRD of specimen from Group B.  
 - SEM view of APICAL THIRD of specimen from Group B.

- Cleaning efficacy of root canals comparing Rotary ProTaperNiTi files and manual NiTi instrumentation in two different groups did not show completely cleaned canals.
- The cleaning efficacy with Manual NiTi files (Group A) instrumentation technique at different levels showed better cleaning of surfaces than rotary ProTaperNiTi files (Group B).
- The irrigants used showed no significant difference between the two groups.

### Discussion

The reason for choosing anterior teeth instead of premolars and molars with curved canals as the study is oriented towards cleaning efficacy rather than cyclic fatigue and torsional resistance.

The main objective of Biomechanical instrumentation is the total elimination of the infected pulp tissue from the root canals including the pulpal remnants, debris and smear layer produced by instrumentation of the root canals walls.<sup>8</sup> In the present study 17% EDTA and 3% NaOCl were used for irrigation of the root canals as it is a recommended combination of both an antimicrobial as well chelating agent to remove debris and inorganic / organic smear layer.<sup>8</sup>

Nickel Titanium files introduced to the field of Endodontic Instruments exhibit super elasticity, a term used to describe the property of certain alloys to return to their original shape upon unloading from even a substantial deformation. The low Modulus of Elasticity of NiTi Instrument permits maintenance of the original canal shape and minimizes iatrogenic errors such as ledging, zipping and canal transportation and demonstrate a superior resistance to fracture when compared with stainless steel instruments.<sup>9</sup> Introduction of SEM evaluation for debris and smear layer at higher magnification was employed for precise evaluation apical, coronal, middle portions were chosen at random for the evaluation.

In our study root canal taper did not affect its debridement. Lee et al<sup>10</sup> and van der Sluis et al<sup>11</sup> prepared root canals with GT files Series 20 and studied the influence of root canal taper on debris removal. According to their results, the increase in taper led to better debridement. Albrecht et al<sup>12</sup> reported that when canals were prepared with GT files size 20, the increase in taper led to better debridement,

whereas when the apical preparation size was 40, taper had no influence on debris removal. Arvanitiet al<sup>13</sup> concluded that that root canal taper can affect its debridement only when final instrument size is smaller than 30.

In the present study, the cleaning efficacy of two instrumentation methods were examined on the basis of separate numerical evaluation of the coronal, middle and apical portions of the canals. In the present study, use of manual Nickel- Titanium produced significantly better removal of debris and smear layer when compared to Rotary protaper technique. While these results corroborate a previous report, in which manual stainless steel hand files proved to superior to profile rotary (NiTi) difference in the present study both files (Hand and Rotary) are made up of Nickel Titanium and irrigant are 3% NaOCl and 17% EDTA is added.

Apical extrusion of material was observed during the manual instrumentation.<sup>14</sup> In the present study, both the procedures showed the presence of smear layer at all levels of root canal, however manual NiTi instrumentation was significantly better in removing debris and smear layer when compared to Rotary ProTaperNiTi technique.<sup>15,16</sup>

The procedure showed the presence of smear layer at all levels of root canal. SEM evaluation for debris and smear layer at higher magnification employed for precise evaluation apical, coronal, middle portions were chosen at random for the evaluation.

So the meticulous way of using the different instruments plays a vital role in the proper bio mechanical preparation of the root canal and thus obtain a better and clean root canal to obtain asepsis.

Studies previously done have not showed much difference in cleaning and shaping of the root canals, when compared between hand and rotary instruments however, a finding in the present study showed rotary ProTaperNiTi technique to be faster compared with the manual technique.<sup>15-17</sup> Yet, the common problem of smear layer was evident at all levels of root canals when observed under magnification. Further research and supplements using the newer file systems, newer irrigation combinations and novel methods for curved canals are necessary to ensure debris and smear layer free root canals.

### Conclusion

Within the parameters of the present study, the following are the conclusions:

1. Both systems of Rotary ProTaperNiTi and manual NiTi files used did not produce completely clean root canals.
2. Manual NiTi files produced significantly less smear layer and debris compared to Rotary protaper instruments.

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