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RESEARCH ARTICLE

# THE EFFECT OF MASTER APICAL FILE SIZE WITH VARIABLE & CONSTANT TAPER ON IRRIGATION & CLEANING OF THE APICAL THIRD OF THE CURVED

**[1,*]Dr. Ravindra Singh Shekhawat, [2]Dr. Avinash A. Patil, [3]Dr. Sanjana A.Patil, [4]Dr. Malini Shankar and [5]Dr. Shipra Singh**

[1,4,5]3rd Year M.D.S., Dept., of Cons & Endo, Kle V.K Institute of Dental Sciences
[2]Reader, Dept. of Cons & Endo, Kle V.K Institute of Dental Sciences
[3]Lecturer, Dept. of Cons & Endo, Kle V.K Institute of Dental Sciences

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**ABSTRACT**

The size, taper & cross-section of an instrument plays a crucial role in cleaning the apical third of a root canal which has a significant amount of debris & smear layer (SL).

The purpose of this study was to evaluate the cleaning efficacy of different sizes and tapers of the MAF (Master Apical File) for penetration of irrigants to the apical third of curved mesiobuccal (MB) canals of first molars.

**Materials and Methods: 7**5 teeth were divided into 5 rotary instrumentation groups (n=14) ProTaper Universal MAF: 20.07 (group1), 25.08 (group2), 30.09 (group3) & K3XF MAF: 25.06 (group4), 30.06 (group5) and a non-rotary instrumentation group (n=5) which served as a control : 20.02 (group6). After instrumentation groups were rinsed with 2 ml of 3% NaOCl for 2 mins & 2ml of 17% EDTA for 1min twice & final flushing with 5 ml of normal saline. In controls only 5ml of saline was used. Efficacy of debridement of the canal was evaluated using **Scanning electron microscopy (SEM)**. The data was analysed using the Post- Hoc & One-way ANOVA & Chi-square test.

**Results:** Groups 30.09, 30.06, 25.08 showed cleaner canals when compared to groups 20.02, 25.07, 25.06 for both debris & smear layer ($p<0.05$).Although group 30.09 showed the best results followed by group 30.06 & group 25.08 the difference however between these three groups was not statistically significant.

**Conclusion:** Within the limitations of the study the minimum appropriate and acceptable debridement was achieved with MAF=25.08 in the curved canals.



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## INTRODUCTION

Success of root canal treatment can be collectively attributed to various important factors, chemo-mechanical preparation undoubtedly remains one of those factors leading to not only removal of microorganisms but also removal of organic tissue and infected dentine leading to a clean canal (Schäfer *et al.*, 2006). Cleaning of root canal is judged by amount of remaining smear layer (SL) and residual debris (Wu *et al.*, 2001). Debris is the pool of dentin chips, pulp remnants and other particles within the intracanal space that remain loosely attached to the canal walls even after biomechanical preparation in areas that are not adequately cleaned by the endodontic files and irrigating solutions (Hülsmann *et al.*, 2003; Rödig *et al.*, 2002). Smear layer (SL) can be defined as the amorphous granular layer which consists chiefly of hydroxyapatite and altered collagen along with ground dentin, predentin, inorganic debris and organic components such as pulp tissue remnants, odontoblastic processes, saliva, blood cells and bacteria. No smear layer is seen on uninstrumented areas (Torabinejad *et al.*, 2002). All the endodontic instruments as a consequence of their usage during the root canal procedure leads to formation of dentine debris and smear layer which is a surface film of thickness 1-2 μm (Pashley, 1984; Foschi *et al.*, 2004).

Thus the SL & debris should be effectively removed because

- SL contains bacteria and protect the bacteria within dentinal tubules
- Penetration of intracanal disinfectant is hindered
- The sealing of root canal filling is compromised (Ashutosh and Aseem, 2011).

Numerous studies have reported that SL removal is less predictable in the apical region as compared with coronal and

***Corresponding author: Dr. Ravindra Singh Shekhawat,**
3rd Year M.D.S., Dept., of Cons & Endo, Kle V.K Institute of Dental Sciences.

middle third of the root (Salzgeber and Brilliant, 1977).Smaller apical canal dimensions hinder the penetration of irrigants and result in limited contact between canal walls and the irrigants (Senia *et al*., 1971). The irrigant penetration into the apical one-third of canal and removal of debris is dependent on the final size of the instrument used in the canals (Bronnec *et al*., 2010). Keeping Schilder's principle of biomechanical preparation in mind of keeping the apical foramen as narrow as possible, the manufacture's recommend increasing root canal taper to obtain an efficient cleaning of the apical third. None of the previous literature have compared the effect of different file sizes with different taper on final cleaning of the apical thirds of the canals. The purpose of our study was to evaluate the cleaning efficacy of different sizes and tapers of the MAF for penetration of irrigants to the apical third of curved MB canals of first molars.

## MATERIALS AND METHODS

### Sample collection

One-hundred and eighty-five extracted human maxillary first molars (due to periodontal disease) were collected.The teeth were decontaminated by immersion in 5.25% NaOCl for 1hr. After obtaining periapical radiographs, all teeth with external or internal root resorption, open apices, visible cracks, fractures, caries, calcification and previous root canal treatment were excluded (Fig.1- the selected 75 samples). After preparing the access cavity (Fig.2- Access opening) & splitting the molar in mesial and distal halves (Fig.3- Splitting the tooth) patency of MB canal was established by gently inserting a size 10 K-file (Dentsply, Maillefer, Ballaigues, Switzerland) until the tip emerged from the apical foramen.

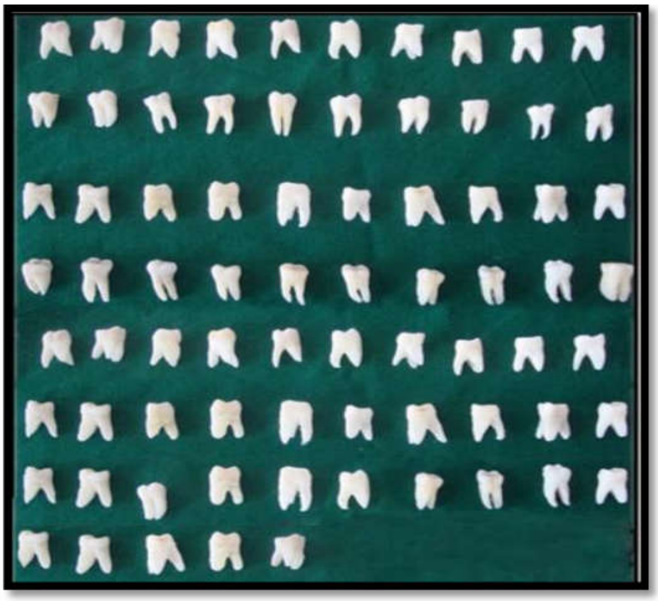


Fig.1- SELECTED 75 SAMPLES

Any root with an apical foramen placed laterally or an apical constriction diameter wider than a size 15 file was excluded. Degree of curvature was determined for the MB canal according to Schneider's method (using parallel radiograph in buccolingual and mesiodistal directions).Only canals with curvatures of 20º-35º were included (F. The selected 75 teeth were decoronated to a standardized root length of 18 mm, with a working length (WL) of 17 mm (Fig.4- WL determination) & (Fig5,6- Standardisation). After coding the teeth, all the samples were instrumented up to size 20 K-file to the WL; then 5 samples were randomly simple randomization method) selected as the control group without rotary instrumentation. Remaining 70 teeth were divided into 5 experimental groups of 14 each.

Fig.2- Access opening

Fig.3- Splitting the tooth

**All the canals were instrumented using manufacturer's instructions**

**Group1 -instrumentation was performed upto size F1 (20.07):** ProTaper Universal NiTi Rotary File system (Dentsply Maillefer, Ballaigues, Switzerland)

**Group2 -instrumentation was performed upto size F2 (25.08):** ProTaper Universal NiTi Rotary File system (Dentsply Maillefer, Ballaigues, Switzerland)

**Group3 -instrumentation was performed upto size F3 (30.09):** ProTaper Universal NiTi Rotary File system (Dentsply Maillefer, Ballaigues, Switzerland)

**Group4 -instrumentation was performed upto size 25 (25.06)**: K3XF NiTi Rotary File system (SybronEndo,Orange, CA, USA)

**Group5 -instrumentation was performed upto size 30 (30.06):** K3XF NiTi Rotary File system (SybronEndo,Orange, CA, USA)

**Group6 -instrumentation was performed upto size 20 (20.02):** (Dentsply, Maillefer, Ballaigues, Switzerland).

**Fig.4- WL determination**

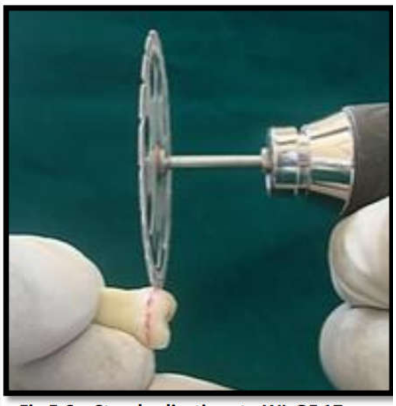


**Fig.5,6 – Standardisation to WL OF 17mm**

During the biomechanical preparation the teeth were mounted on a bench clamp. After each rotary file, the canal was rinsed with 2ml of 3% NaOCl (Vishal Dental Care,Ahemdabad), delivered by using a disposable 26-guage needle syringes (Unolok,Faridabad) inserted deeply and passively from coronal to middle third. Finally the specimens were rinsed with 2 ml of 3% NaOCl for 2 mins & 2ml of 17% EDTA for 1min twice.Final flushing with 5 ml of normal saline was done to eliminate the irrigation solutions from the canals. In controls only 5ml of saline was used.

**Fig.7- Split tooth section**


**Fig.8- Scanning electron microscope**

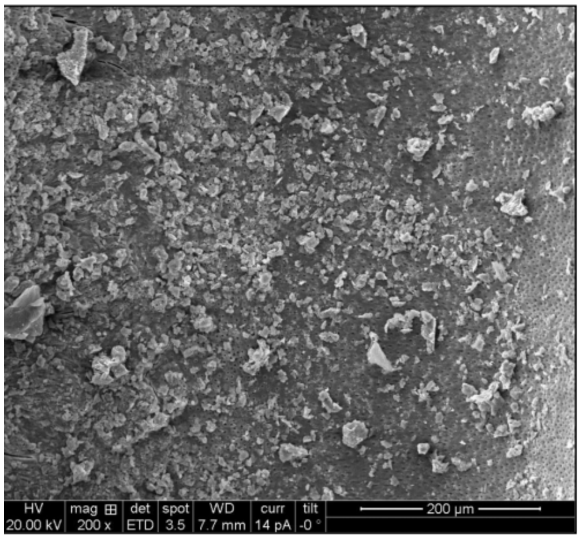



**Fig.9. SCORE 4: SEM image of apical 3mm of a canal prepared with ProTaper Universal NiTi rotary instrumentation system (Group1) - 20.07 showing residual debris**

### SEM sample preparation and evaluation

Two grooves were prepared in the mesial and distal walls. All the teeth were grooved using a diamond disc on the external surface to avoid penetration of the root canals. The teeth were carefully split using chisel and mallet and finally prepared for SEM examination (Fig.7- split tooth section).The amount of debris and SL at the apical third of both root halves of each sample was separately scored according to Schäfer and Schlingemann (Ahlquist *et al*., 2001). After SEM analysis at a magnification of 200X & 1000X respectively by the technician who was blinded for the samples (Fig.8- Scanning electron microscope).

### Schafer & Schlingeman classification was used for scoring (Ahlquist *et al*., 2001)

### Statistical Analysis

Statistical analysis was performed using the SPSS software (version 19). The data was analysed using the Post- Hoc & One-way ANOVA & Chi-square test. ($p<0.05$)

## RESULTS

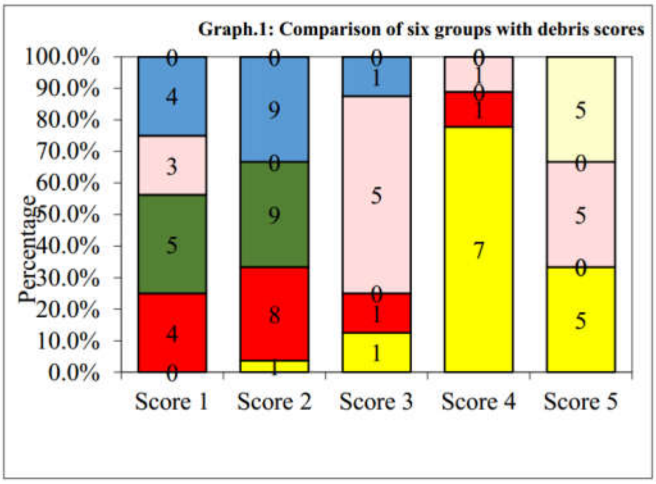
**(Table 2- scores of residual debris) & (Table.3- scores of residual SL)**

**Table 1. Scoring criteria used for assessment of different file systems**

| Scores | Smear Layer | Debris |
|---|---|---|
| 1 | No SL, orifices of the dentinal tubules patent | Clean canal wall, only very few debris particles |
| 2 | Small amount of SL, some open dentinal tubules | Many conglomerations |
| 3 | Homogeneous SL along almost the entire canal wall, with only very few open dentinal tubules | Many conglomerations, less than 50% of the canal wall covered; |
| 4 | The entire root-canal wall covered with a homogeneous SL, with no open dentinal tubules | More than 50% of the canal wall covered |
| 5 | A thick homogeneous SL covering the entire root-canal wall | Complete or nearly complete covering of the canal wall by debris |

**Table 2. Scores of residual debris**

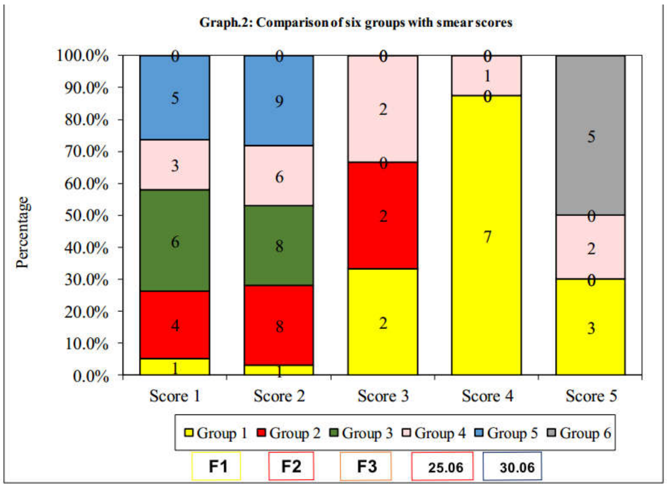
| GROUP | ACCEPTABLE 1 | 2 | UNACCEPTABLE | | |
|---|---|---|---|---|---|
| G-6 CONTROL | 0 | 0 | 0 | 0 | 100% (5) |
| G-1 20 (7%) | 0 | 7.1% (1) | 7.1% (1) | 50% (7) | 35.8% (5) |
| G-2 25 (8%) | 28.6% (4) | 57.2% (8) | 7.1% (1) | 7.1% (1) | 0 |
| G-3 30 (9%) | 35.7% (5) | 64.3% (9) | 0 | 0 | 0 |
| G-4 25 (6%) | 21.4% (3) | 35.7% (5) | 35.7% (5) | 7.1% (1) | 0 |
| G-5 30 (6%) | 28.6% (4) | 64.3% (9) | 7.1% (1) | 0 | 0 |



Graph.1: Comparison of six groups with debris scores

**Table 3. Scores of residual SL**

| GROUP | ACCEPTABLE 1 | 2 | UNACCEPTABLE | | |
|---|---|---|---|---|---|
| G-6 CONTROL | 0 | 0 | 0 | 0 | 100% (5) |
| G-1 20 (7%) | 7.1% (1) | 7.1% (1) | 14.3% (2) | 50% (7) | 21.5% (3) |
| G-2 25 (8%) | 28.6% (4) | 57.1% (8) | 14.3% (2) | 0 | 0 |
| G-3 30 (9%) | 42.8% (6) | 57.2% (8) | 0 | 0 | 0 |
| G-4 25 (6%) | 21.7% (3) | 42.8% (6) | 14.2% (2) | 7.1% (1) | 14.2% (2) |
| G-5 30 (6%) | 28.6% (5) | 64.3% (9) | 0 | 0 | 0 |



Graph.2: Comparison of six groups with smear scores

Groups 30.09, 30.06, 25.08 showed cleaner canals when compared to groups 20.02, 25.07, 25.06 for both debris & SL ($p<0.05$).

Although group 30.09 showed the best results followed by group 30.06 & group 25.08 the difference however between these three groups was not statistically significant. (Graph1: Comparison of 6 groups with residual debris scores) & (Graph2: Comparison of 6 groups with residual smear scores) (Fig.9,10,11,12,13,14,15,16,17,18,19,20).

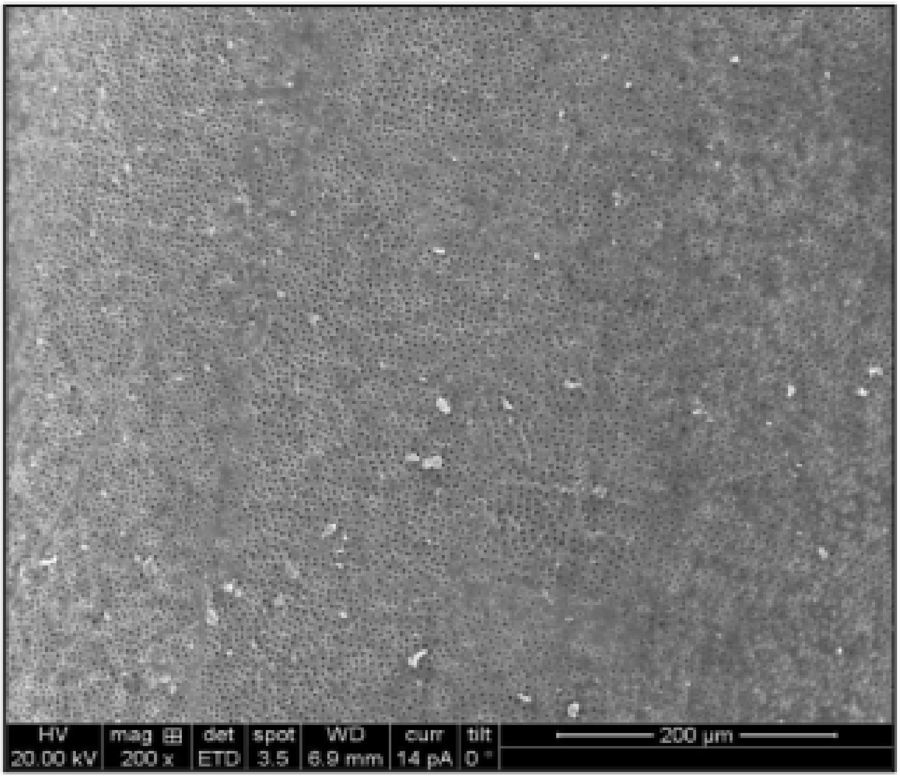



**Fig.10. SCORE 3: SEM image of apical 3mmof a canal prepared with ProTaper Universal NiTi rotary instrumentation system (Group2)- 25.08 showing residual debris**

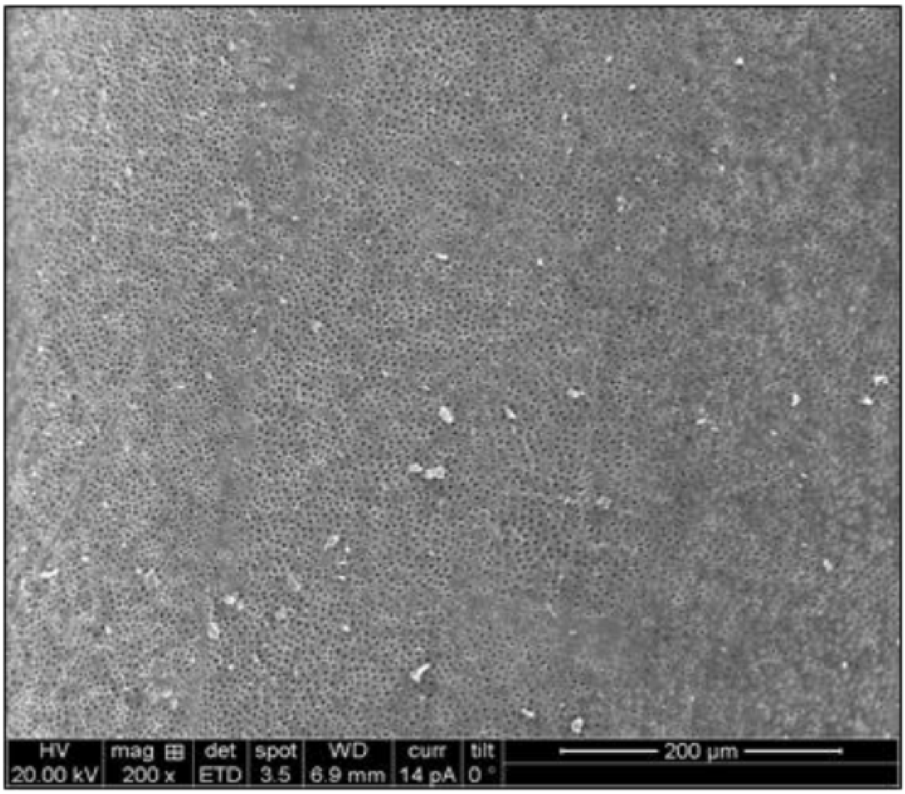



**Fig.11. SCORE 1: SEM image of the apical 3mm of a canal prepared with ProTaper Universal NiTi rotary instrumentation system (Group3) - 30.09 showing residual debris**

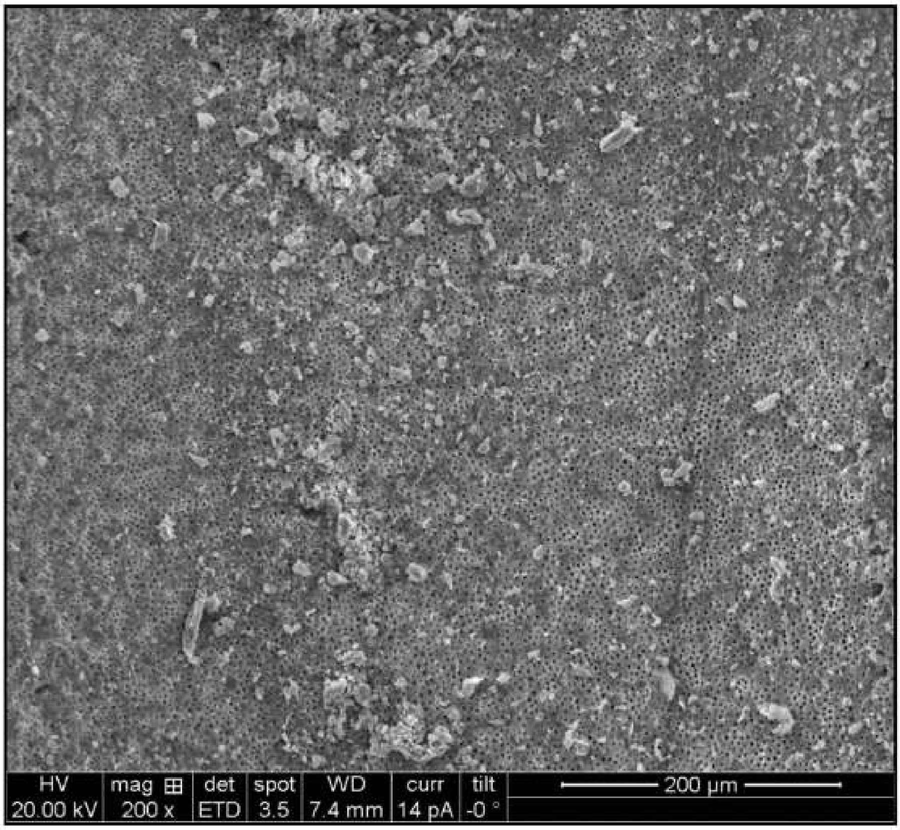



**Fig.12. SCORE 4: SEM image of apical 3mm of a canal prepared with K3XF NiTi rotary instrumentation system (Group4) - 25.06 showing residual debris**

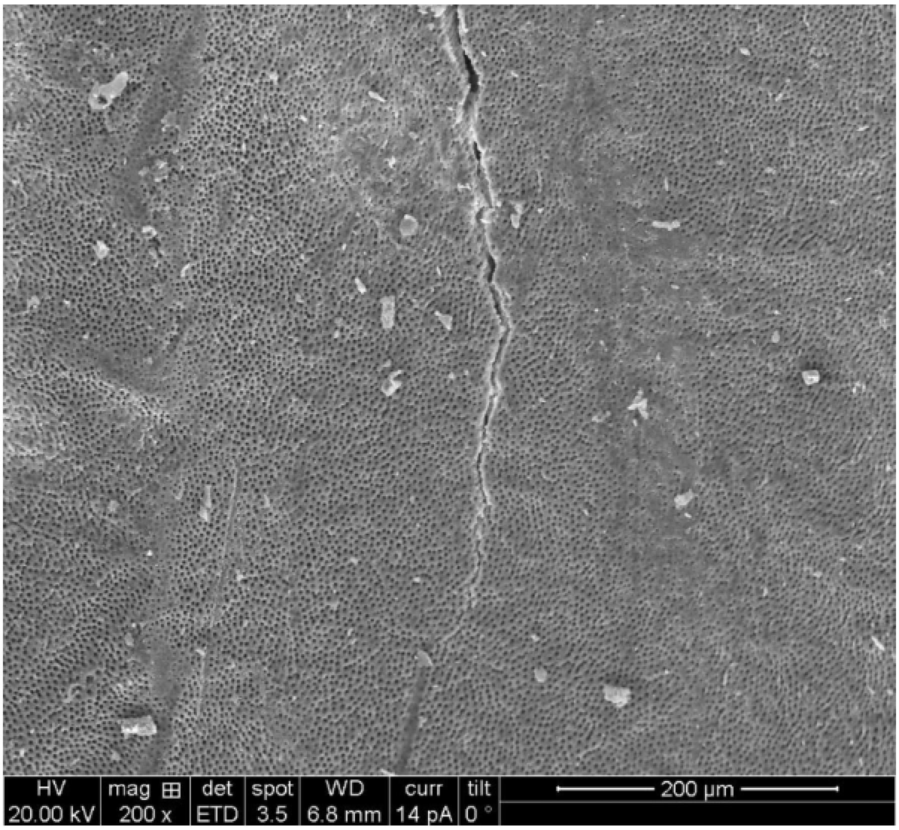



**Fig.13. SCORE 2: SEM image of apical 3mm of a canal prepared with K3XF NiTi rotary instrumentation system (Group5) - 30.06 showing residual debris**

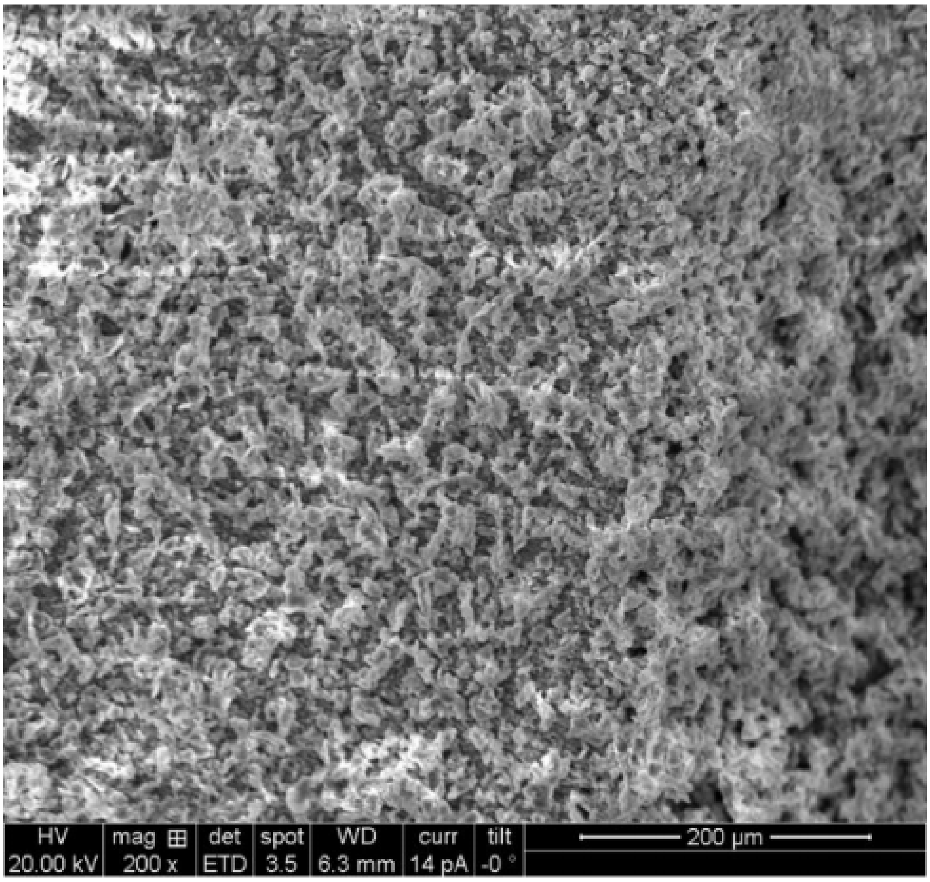



**Fig.14- SCORE 5: SEM image of apical 3mm of a canal prepared with non- rotary instrumentation system (Group6) - 20.02 showing residual debris**

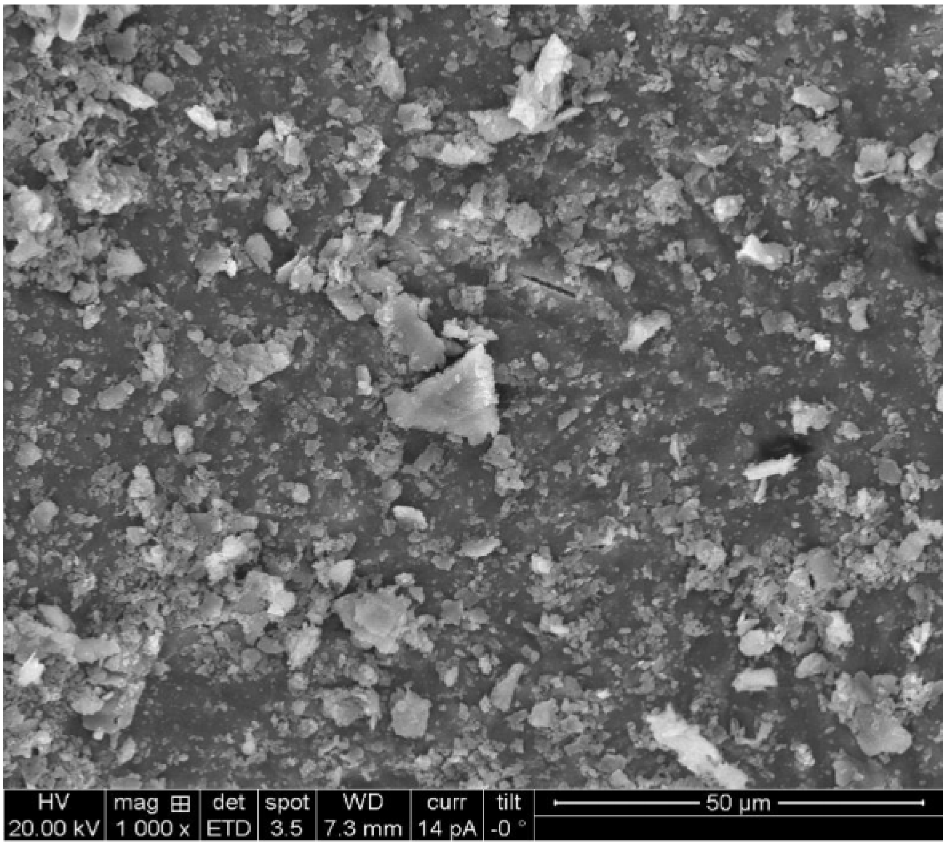



**Fig.15-SCORE 5: SEM image of apical 3mm of a canal prepared with non- rotary instrumentation system (Group1) – 20.07 showing remaining smear layer**

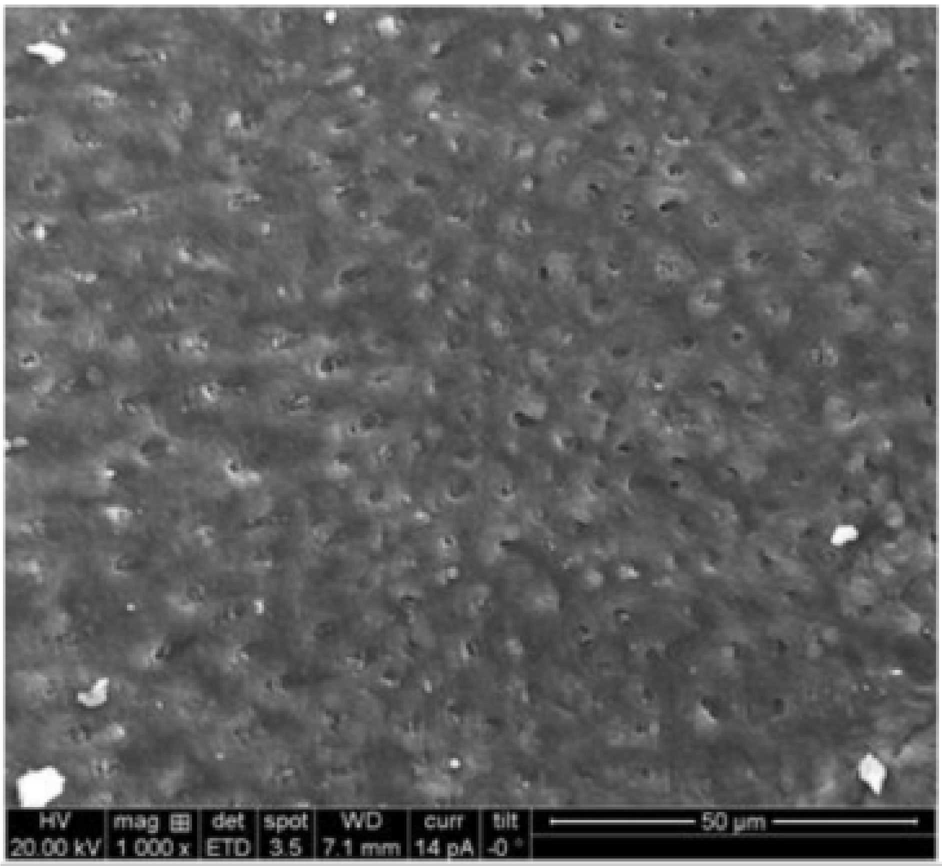



**Fig.16-SCORE 3: SEM image of apical 3mmof a canal prepared with ProTaper Universal NiTi rotary instrumentation system (Group2)-25.08 showing remaining smear layer**

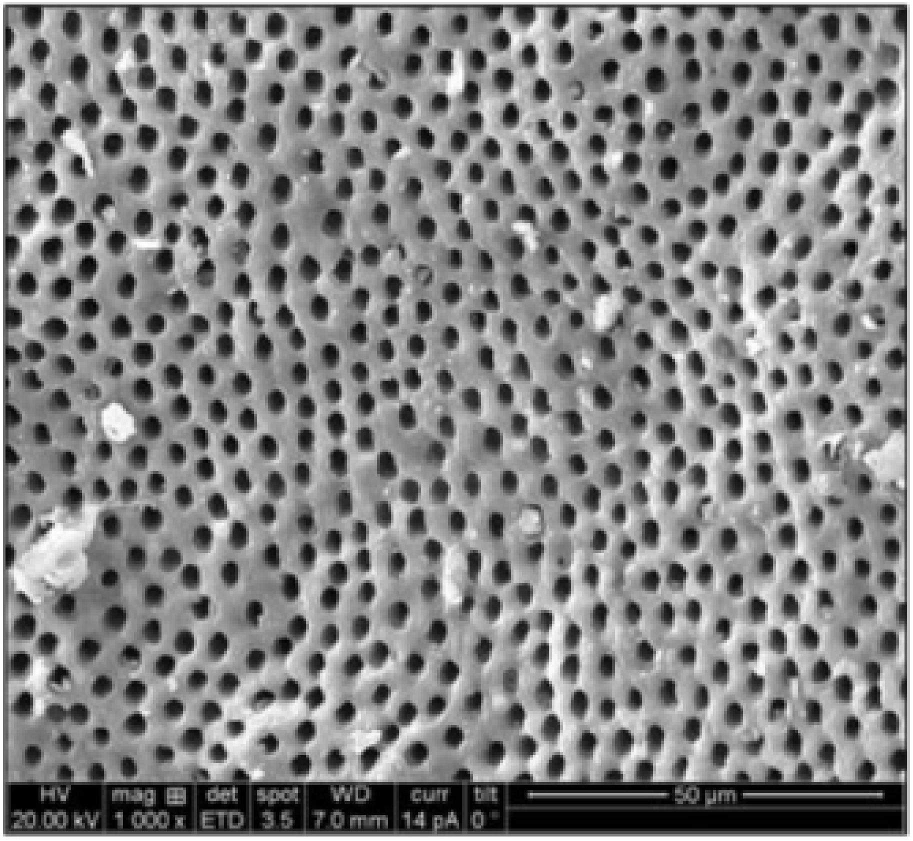



**Fig.17-SCORE 1: SEM image of the apical 3mm of a canal prepared with ProTaper Universal NiTi rotary instrumentation system (Group3) - 30.09 showing remaining smear layer**

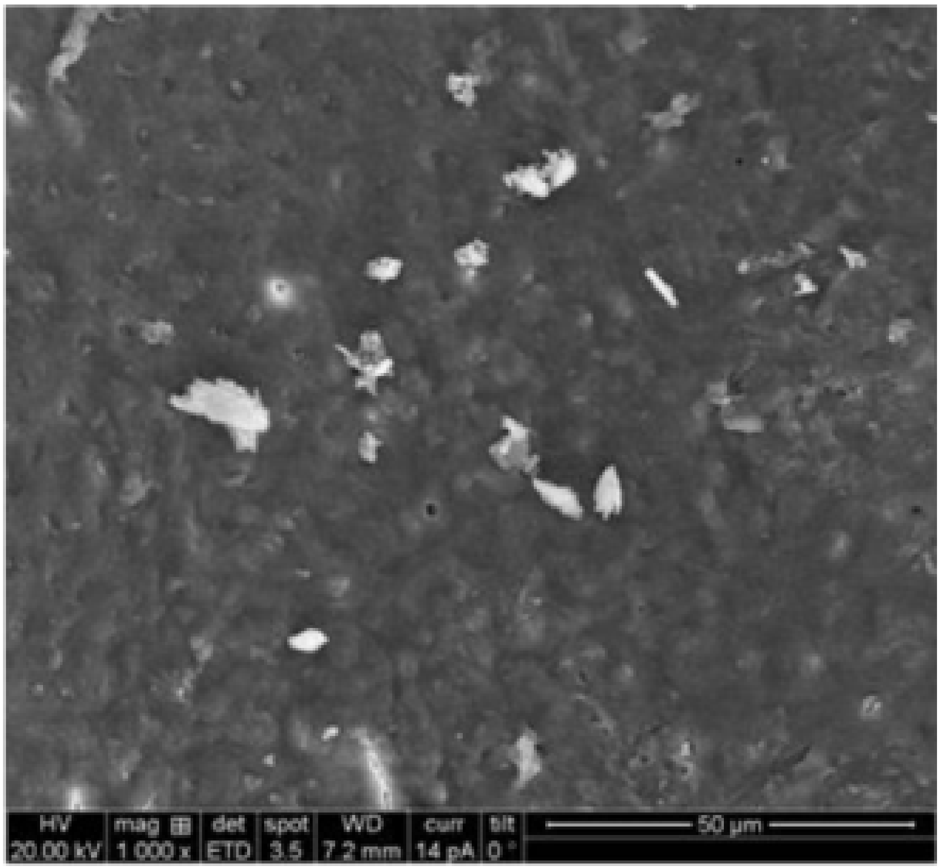



**Fig.18- SCORE 4: SEM image of apical 3mm of a canal prepared with K3XF NiTi rotary instrumentation system (Group4) - 25.06 showing remaining smear layer**

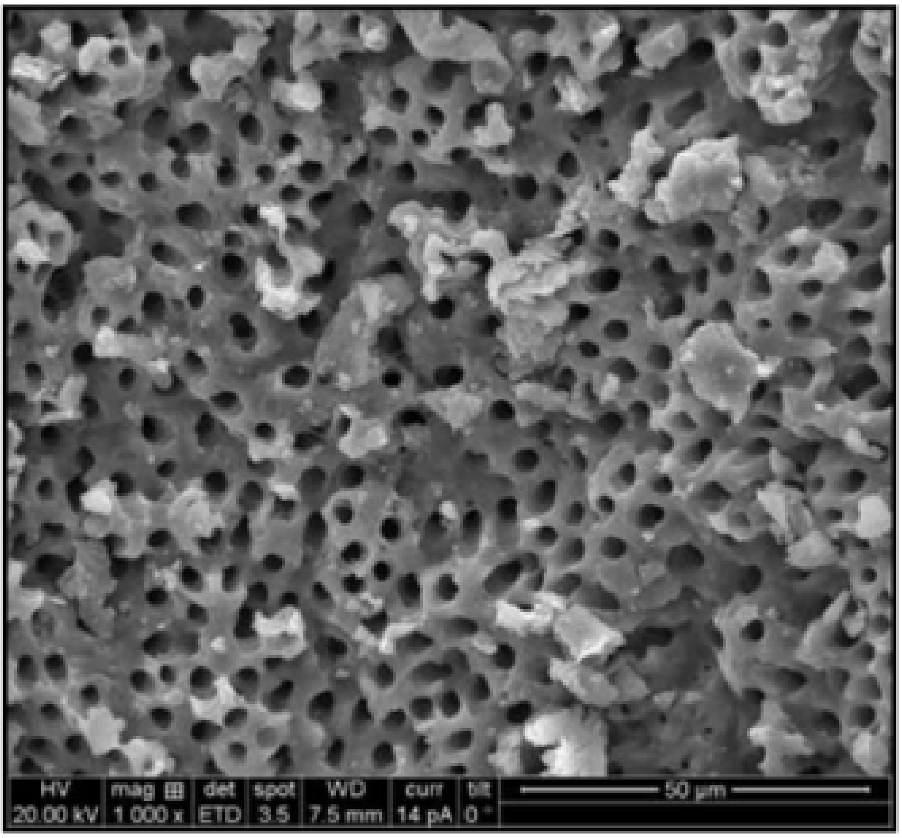



**Fig.19- SCORE 2: SEM image of apical 3mm of a canal prepared with K3XF NiTi rotary instrumentation system (Group5) - 30.06 showing residual debris**

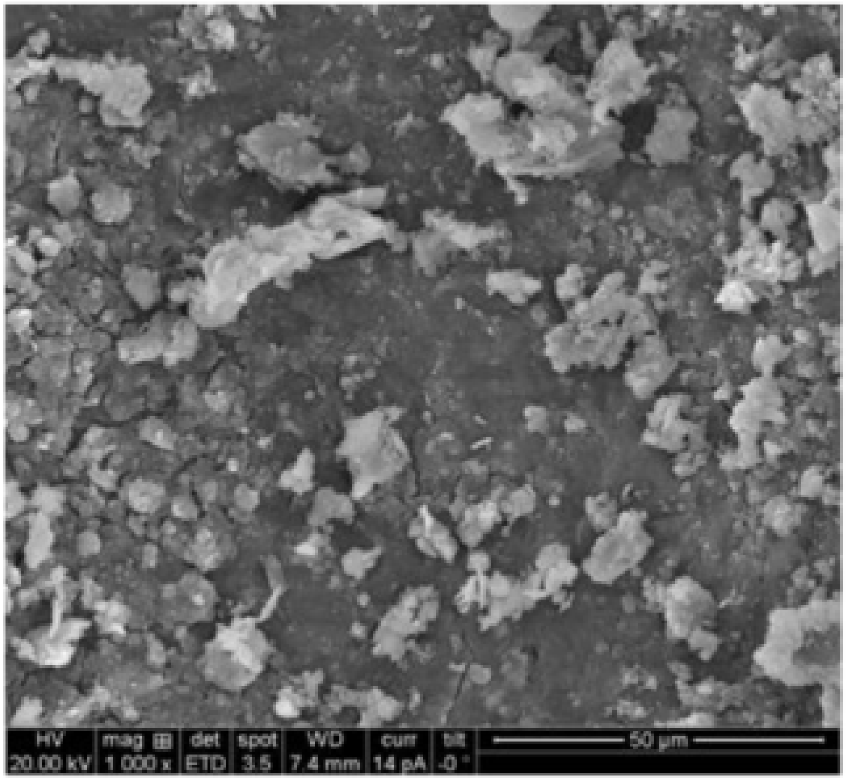



**Fig.20-SCORE 5: SEM image of apical 3mm of a canal prepared with non- rotary instrumentation system (Group6) - 20.02 showing remaining smear layer**

## DISCUSSION

The extent of apical enlargement has always been a matter of debate. Historically, the “three sizes up from the first file to bind,” rule is still being used in modified forms even now (Albrecht, ?). Minimal apical enlargement has been suggested to conserve tooth structure and limit extrusion of filling materials (Buchanan, 2001). Two most common types of rotary files are available to accomplish the procedure of biomechanical preparation which are - the progressive taper files & the constant taper files respectively. In this study, the classical ProTaper Universal system (crown down technique) used has a convex triangular cross section which minimizes the contact between the file and the canal, decreasing the load and increasing the efficiency of the file. The angle and the pitch of the cutting blade continuously keeps changing along the length of the cutting flutes to ensure effective dentine removal and stops the file from being pulled and screwed into the canal (Ruddle, 2001; Ruddle, 2001).

The progressive taper design is a unique feature of ProTaper Universal files, wherein each file has multiple, increasing percentage tapers of its cutting blades. This design significantly improves the flexibility, cutting efficiency and reduces the number of recapitulations the file needs to reach the working length (Ruddle, 2001; Ruddle, 2001). K3 Nickel titanium rotary system in 2009 was modified to K3XF which had the similar features and manufacturing as the original file, however after grinding the K3XF files followed a thermal treatment called as R-phase treatment which lead to greater resistance and increased cyclic fatigue of these files compared to their original K3 counterparts. This K3XF Nickel titanium rotary system (crown down technique) used in this study have an asymmetrical design and these files are characterized by a positive rake angle which provides an effective cutting surface, variable core diameter enhances the flexibility over the entire cutting length. It also has 3 radial lands out of which the 3$^{rd}$ radial land keeps the instrument centered in the canal and prevents over engagement. With relief behind two of the three radial lands, it reduces the friction on the canal wall.

Asymmetrically placed radial lands and unequal land widths, flute widths and flute depths allow K3XF rotary system to have a superior canal tracking, eliminating canal transportation practically and also aid in preventing the file from screwing in the canal and add peripheral strength (Gambarini *et al*., 2011). *Williamson AE, Sander* (Williamson *et al*., 2009) reported that by means of SEM, the cleaning efficacy of curved root canals could be very well demonstrated. Photomicrographs for residual debris scores and remaining smear layer scores were taken at a magnification of 200x and 1000x respectively in the apical thirds of the one half of the split roots. The 6 prepared groups were coded and the SEM observation was done randomly by a second operator who was blinded and had no information about the prepared groups at all. In previous studies, different magnifications ranging from 45x to 2500x have been used. Even though at low magnification large amounts of debris can be easily seen, to view greater details such as the remaining smear layer or identification of dentinal tubules a greater magnification is required. A disadvantage of using higher amount of magnification is the small size of the area of evaluation, potentially leading to misinterpretation

(Mayer *et al*., 2002; Schäfer and Zapke, 2000; Ahlquist *et al*., 2001). Keeping this in mind a magnification of 200x and 1000x was used for our study which was recommended by Hulsmann *et al.* (1997)

The biomechanical preparation widens the apical canal enough for placement and replacement of irrigation solution and for the placement of intracanal medicament. On the other side, it should not be so wide that it weakens the root canal. *Dulton et al.* (2002) showed that with increasing file size, there was an increased reduction in bacteria and also increase risk of fracture. 3% NaOCl was used as an irrigant of choice & 15% EDTA in gel form was used to facilitate instrumentation of the root canals thereby making the negotiating and the instrumentation of the root canals easier (Naenni *et al*., 2004). 3% NaOCl and 17% EDTA (aqueous form) are an effective combination in removing the Smear layer from the canals (Khademi and Feizianfard, 2004). Results of our study showed significant differences between groups 25.08 and 25.06. However, there were no significant differences between each of the 30.09, 25.08 and 30.06 groups. These groups showed acceptable debridement. Our findings showed that increased size and taper of MAF at WL improved debris and SL removal. One possible explanation is that the increased taper allowed for deeper penetration of irrigation, increased volume of irrigant solution in contact with the canal and improved flushing of debris. This is in agreement with *Fornari et al* (2010) who have found cleaner canals with larger apical preparations in severely curved roots when final instruments of greater diameter are used, but this greater enlargement and apical patency may result in material extrusion to the periapical region causing persistent inflammation and postoperative pain. Thus, it is important to reach a balance between using final instruments with greater diameter of during root canal shaping and the amount of material extruded to the periapex. In the present study, MB canals of first molars with a similar root curvature (20°–35°) were prepared using Protaper Universal & K3XF rotary systems.

*Schäfer et al.* (2003) reported that debridement of the apical third of the canals was less than the middle and coronal thirds; & since the progressive taper files have a similar taper only in the apical 3 mm of the files when compared to constant taper which have the same taper throughout their length, only the apical 3mm of MB canals was evaluated in our study. According to *Gopikrishna et al.* (2010) apical 3mm mm of the root canal system is the most crucial area to be cleaned in order to achieve clinical success, the only clinical parameter one has to keep in mind is to ensure that the chosen system is able to enlarge the canal to size #50 at a level 3 mm short of the working length. This is in accordance to our study where the group2 (#25.08) , group5 (#30,06) were more or less at the same canal size at 3mm short of working length which was 49 & 48 respectively. *Khademi et al.* (2006) also showed that MAF # 30.06 was effective for the removal of debris and SL from the apical portion of root canals which is in accordance with our study. It appears unnecessary to remove dentine in the apical part of the root canal when a suitable coronal taper is achieved. Although the results showed that increasing the taper from .06 to .08 in file #25 led to statistically significant SL & debris removal, increasing the taper from 0.06 to 0.09 in file #30 did not led to statistically significant results. This finding is supported by Arvaniti and Khabbaz (2011) who reported that root canal taper can affect debridement only when the final instrument size was smaller than 30. However, Senia *et al.* (2007) showed minimum penetration of NaOCl to the apical part of the canals enlarged up to #30 files. These findings were not in agreement with our study. The probable reason might be the taper of the instrument and irrigation protocol in our study.

**Conclusion**

Within the limitations of the study the minimum appropriate and acceptable debridement was achieved with MAF=25.08 in the curved canals. Further studies are needed to verify apical cleaning and extruded material in root canals prepared with various rotary instruments & latest irrigation techniques.

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