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Syed Mukhtar-Un-Nisar Andrabi

Department of Conservative Dentistry and Endodontics, Dr. Ziauddin Ahamd Dental College, Aligarth Muslim University, Aligarth, India, mukhtarandrabi@gmail.com

Ashok Kumar

Department of Conservative Dentistry and Endodontics, Dr. Ziauddin Ahamd Dental College, Aligarth Muslim University, Aligarth, India

Rajendra Kumar Tewari

Department of Conservative Dentistry and Endodontics, Dr. Ziauddin Ahamd Dental College, Aligarth Muslim University, Aligarth, India

Surendra Kumar Mishra

Department of Conservative Dentistry and Endodontics, Dr. Ziauddin Ahamd Dental College, Aligarth Muslim University, Aligarth, India

Huma Iftekhar

Department of Conservative Dentistry and Endodontics, Dr. Ziauddin Ahamd Dental College, Aligarth Muslim University, Aligarth, India

See next page for additional authors

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Authors

Syed Mukhtar-Un-Nisar Andrabi, Ashok Kumar, Rajendra Kumar Tewari, Surendra Kumar Mishra, Huma Iftekhar, and Afaf Zia

ORIGINAL ARTICLE

Effect of the Extent of Apical Enlargement on the Degree of Debridement of the Apical Third in Curved Root Canals

Syed Mukhtar-Un-Nisar Andrabi¹, Ashok Kumar¹, Rajendra Kumar Tewari¹, Surendra Kumar Mishra¹, Huma Iftekhhar¹, Afaf Zia²

¹*Department of Conservative Dentistry and Endodontics, Dr. Ziauddin Ahamd Dental College, Aligarh Muslim University, Aligarh, India*

²*Department of Periodontics and Community Dentistry, Dr. Ziauddin Ahamd Dental College, Aligarh Muslim University, Aligarh, India*

Correspondence e-mail to: mukhtarandrabi@gmail.com

ABSTRACT

Objectives: The present study aimed to evaluate the influence of various apical instrumentation sizes and tapers on the degree of debridement of the apical third of curved root canals. **Methods:** We used 60 extracted human mandibular first molars with mesial root curvatures of 20° to 30°. In all teeth, access cavity preparation was performed, followed by coronal flaring with Gates Glidden drills #1–4 (Dentsply Maillefer). Specimen teeth were subsequently randomly divided into five groups (n = 12). Each group was enlarged to a particular apical size and taper as follows: no apical preparation done (group I, Control group); 25/04 and 25/06 (Group II); 30/04 and 30/06 (group III); 35/04 (group IV); 40/04 (group V). Specimens were rinsed with 17% EDTA and 3% NaOCl solutions. We used a scanning electron microscope to evaluate specimens' degree of debridement. Retrieved data were analyzed using Kruskal–Wallis and Mann–Whitney *U*-tests ($p < 0.05$). **Results:** Acceptable debridement was observed in groups III, IV, and V. Additionally, debridement was significantly better in Groups IV and V than in group II. **Conclusion:** Apical preparation with <30/04 size results in an unacceptable degree of debridement of the apical third.

Key words: root canal preparation, curved canal, apical instrumentation, apical third, smear layer

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INTRODUCTION

The main objective of root canal therapy is to minimize the number of microorganisms and pathologic debris in root canal systems. This is performed to create an environment favorable for the healing of the peri-radicular tissues. Microbial growth within the root canal system is most commonly controlled by chemomechanical debridement. The process of chemomechanical debridement is based on the removal of all the contents of the root canal systems before and during shaping.¹ Specifically, it has been shown that mechanical cleaning is the most important part of the root canal therapy and a foundation for successful treatment.^{2,3} Furthermore, mechanical instrumentation of the root canal system is required for the creation of a desired shape. The latter in turn acts as a reservoir for the irrigants and the medicaments, further enhancing

the debridement and disinfection process. Several studies suggest that mechanical instrumentation and irrigation form essential components of successful endodontic therapy.^{4,5} Mechanical instrumentation alone is very effective in reducing the number of intracanal microorganisms.⁶ Endodontic failures are predominantly caused by inadequate cleaning, debridement, and disinfection, particularly when they occur in the apical third region of the canal. The apical third of the root canal system has been described as the most critical area for instrumentation as early as 1931 by Groove⁷ and later several other authors^{8,9} also confirmed the importance of the instrumentation of the apical third region. The extent of apical enlargement, however, has been a matter of debate. With the introduction of various rotary and reciprocating systems of nickel titanium instruments a wide range of canal preparation strategies have been

advocated. Most of these techniques are suggested by the manufacturers based on the ease of preparation and the method of obturation to be used while the biologic basis of the endodontic disease is ignored.

As a consequence, current instrumentation systems predominantly emphasize on reducing the number of instruments and limiting apical preparations to small sizes, which may not lead to the production of clean apical preparations in diseased teeth.⁹ Based on these key observations, we evaluated the influence of different sizes and tapers of apical instrumentation on the degree of debridement of the apical third in curved root canals.

METHODS

Sample Selection

In this study, we collected 115 human mandibular first molars extracted following periodontal reasons and characterized by curved mesial roots. The teeth were selected from the tooth bank of Department of Oral and Maxillofacial Surgery of Dr Z A Dental College, AMU Aligarh, India. Teeth with external or internal root resorption, open apices, visible cracks, fractures, caries, calcification and previous root canal treatment were excluded. After access cavity preparation, the presence of two separate mesial canals was confirmed and then patency was established with a ISO #10k-file (Dentsply, Maillefer, Ballaigues, Switzerland). Working length was established 1mm short of the length at which the tip of a no. 10 k file was just visible at the apex. Teeth with laterally placed apical foramen or an apical constriction diameter wider than a size of ISO #15 k-file were excluded. The degree of curvature of the mesiobuccal root canals was determined according to Schneider's method.¹⁰ Canals with curvatures of 20° -30° were included. Finally, 60 teeth meeting all the inclusion criteria were used in this study. All the specimen teeth were decoronated to a standard length of 17 mm. Coronal flaring was done with Gates Glidden drills #1-4 (Dentsply Maillefer). Next both mesial canals in all teeth were prepared to working length with a size ISO #15 k-file. The specimen teeth were then randomly divided into five groups (n=12) with each group enlarged to a particular apical size and taper. The root canal instrumentation was done with *HyFlex® CM NiTi files* (Coltène/Whaledent Inc.) at 2.5NM torque and 500rpm speed. The apical third of all specimens in each group was prepared to particular size and taper as follows: Group I: no apical preparation done (Negative Control Group) Group II: 25/.04 and 25/.06 Group III: 30/.04 and 30/.06 Group IV: 35/.04 Group V: 40/.04.

Irrigation was performed with 2ml of 3% NaOCl in between each file with a 30-gauge side vented needle inserted passively as far as it did not bind in the canal. During the apical preparation needle penetrated up

Table 1. Scores for smear layer (SL) and debris removal (Schäfer and Schlingemann classification)

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

to the apical 3 mm of the canal. Final irrigation was done with 3ml of alternating solutions of 3% NaOCl and EDTA for 1 minute each. The irrigating solutions were manually activated by a gutta-percha point corresponding to the final apical preparation size. The master gutta-percha point was placed to working length and then moved in push-pull motions for 30 s at an approximate frequency of 100 times per minute. The canals were finally rinsed with 5 ml of distilled water to rid of any residual amount/activity of irrigants. After this the canals were dried with absorbent points and scheduled for sectioning.

Sectioning of Roots

A horizontal non-penetrating groove was placed around the roots at 5 mm from the apex and also two longitudinal non-penetrating grooves were placed on buccal and lingual side of the roots. With the aid of a chisel, the teeth were then split into two halves, resulting in 24 samples per group. Each group's samples were coded and scheduled for evaluation by scanning electron microscope (SEM).

SEM Evaluation

The coded samples were processed as follows: 1. dehydrated with ascending concentrations of ethyl alcohol (30%–100%); 2. placed in a desiccator for a minimum of 24 h; 3. mounted on metallic stubs, gold-sputtered; 4. observed under a SEM (2 nm at 30 kV 500× to 1000×; JSM 6510 LV, Jeol, Japan) for debris and smear layer removal. For all samples, images with a magnification of 500x and 1000x were taken. Subsequently, images were analyzed to determine the amount of debris and smear layer present on the samples. Three blinded independent observers performed the analysis. To ensure intra-examiner

Table 2. Evaluation of debris and smear in the groups (values indicate the percentage of samples falling under a particular score for smear layer and debris)

Groups	Smear Score					Debris Score				
	Acceptable Debridement		Unacceptable Debridement			Acceptable Debridement		Unacceptable Debridement		
	1	2	3	4	5	1	2	3	4	5
I	0	0	0	0	100	0	0	0	0	100
II	0	7.2	13.4	67	13.4	0	8.3	24.6	56.4	10.6
III	8.6	49.4	28.6	13.2	0	7.3	42.8	38.4	11.6	0
IV	18.8	56.4	22.4	2.4	0	28.6	58.4	13.2	0	0
V	23.2	69.4	6.4	0	0	30.5	64.3	5.2	0	0

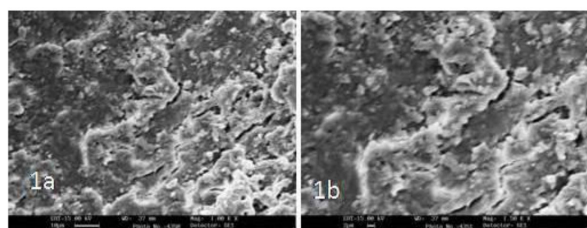


Figure 1a-b. Representative SEM images of Group I (Control Group).

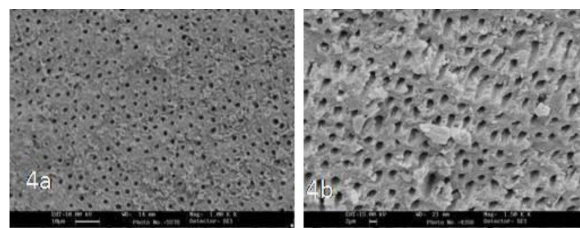


Figure 4a-b. Representative SEM images of Group III (30/.04).

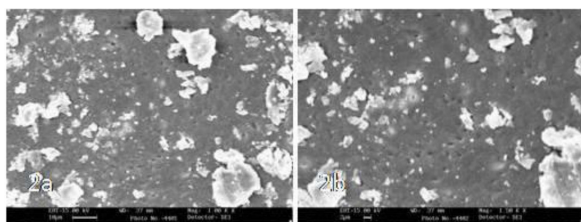


Figure 2a-b. Representative SEM images of group II (25/.04).

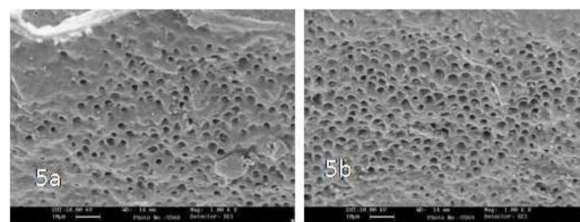


Figure 5a-b. Representative SEM images of Group IV (35/.04).

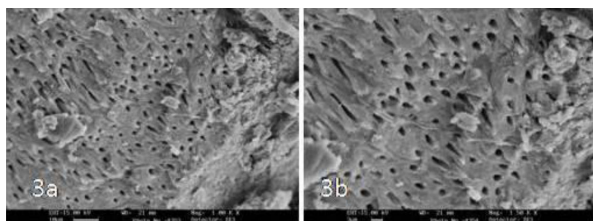


Figure 3a-b. Representative SEM images of group II (25/.06).

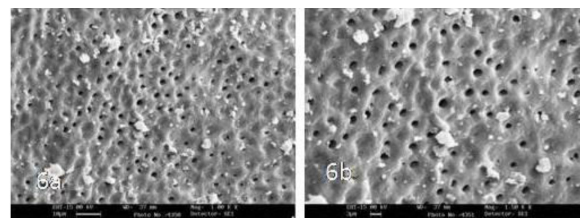


Figure 6a-b. Representative SEM images of Group V (40/.04).

consistency, evaluation was repeated twice for the first 10 specimens. Schäfer and Schlingemann's¹¹ criteria were used to evaluate the debris and smear layer present on each sample (Table 1). A 5-score system was used. Specifically, Scores 1 and 2 indicated acceptable debridement and scores 3, 4, and 5 indicated unacceptable debridement.

Statistical Analysis

Comparison among all the groups with respect to different apical sizes was done using the Kruskal-

Wallis test ($p < 0.05$) and comparison within the groups with respect to different tapers was done using Mann-Whitney U test ($p < 0.05$).

RESULTS

Table 2 describes the results of comparison of debris between groups. No sample within the control group showed acceptable debridement (Figure 1a-b). For group II (25/0.04) only 7.2 % samples showed

acceptable debridement for smear layer and for debris it was only 8.3% (Figure 2a-b). For group III (30/0.04) 50.1% samples showed acceptable debridement for smear layer while for debris it was 58% (Figure 4a-b). For group IV (35/0.04) 75.2% samples showed acceptable debridement for smear layer while for debris it was 87% (Figure 5a-b). For group V (40/0.04) 92.6% samples showed acceptable debridement for smear layer while for debris it was 94.8% (Figure 6a-b). No significant difference in debridement was found when comparing 25/0.04 (Figure 2a-b) and 25/0.06 (Figure 3a-b), both resulted in unacceptable debridement. Comparison of 30/0.04 and 30/0.06 showed significantly better debridement for 30/0.06 (58.3%) than 30/0.04 (50.1%).

DISCUSSION

The apical third area of the root canal system is an anatomically complex region that plays a major role in root canal instrumentation. In infected root canal systems, the apical portion can retain microorganisms that could potentially lead to periradicular inflammation. When instrumenting the region, treatment should be directed toward the maximal removal of pathogens from infected root canals by removing the heavily infected dentin.¹² Such an approach is necessary because studies^{12,13} have shown that the apical microflora can play an important role in post-therapy endodontic treatment failures.

Increasing of the apical size facilitates removal of the apical infected dentin and also enhances the efficacy of irrigation, thus improving the overall debridement of the apical third. It has been shown that increased canal enlargement results in significantly less bacteria remaining in the root canal system.¹⁴ Several *in vitro* studies¹⁵⁻¹⁷ have shown that by increasing the apical enlargement, an improvement of the mechanical debridement of particles and debris is observed. Brunson et al.¹⁸ demonstrated that the use of K3 rotary instruments (size 40.04) will allow for maximum volume of irrigation at the apical third of single-rooted teeth when using the apical negative pressure irrigation system. Furthermore, Wu and Wesselink¹⁹ have recommended enlarging the canals to sizes over #40 file, to achieve a more efficient removal of debris and a better cleaning of the apical thirds of the root canals.

There is a general consensus that a better microbial removal and more effective irrigation are achieved when canals are instrumented to larger apical sizes.^{20,21} This in turn promotes the treatment's success.²²⁻²⁵ As a result, failing to clean the canals thoroughly, especially in the apical region, can result in treatment failure.^{12,13} In the present study, we aimed at evaluating the influence of size and taper of the apical instrumentation on debridement in the apical third region of the curved

canals. Results of our study showed that apical preparation sizes of 25/0.04 and 25/0.06 failed at yielding an acceptable debridement of the root canals. Apical preparation sizes greater than 30/0.04 demonstrated an acceptable debridement of the apical third. Additionally, the debridement appeared to be significantly improved for 35/0.04 and 40/0.04. Therefore, we defined in the present study that the minimum apical preparation size was 30/0.04.

CONCLUSIONS

In the present study, we determined that the minimum apical preparation size to achieve an acceptable debridement in curved mesiobuccal root canals is 30/0.04. A more complete debridement can be achieved with apical preparation sizes of 35/0.04 and 40/0.04. Apical preparation sizes should not be kept as small as possible; rather they should be as large as practical. Further research is required to establish the appropriate size of apical instrumentation.

CONFLICT OF INTEREST

The author declares no conflict of interest related to this study.

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