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Master file size and apical transportation in severely curved root canals

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ABSTRACT

Objectives A curvature leads to asymmetrical removal of root dentine, which results in an increase in the incidence of canal transportation. The aim of this study was to evaluate the effect of master apical file (MAF) size on the apical transportation (AT) of teeth with severe canal curvatures.

Methods Thirty-six mesial roots of human mandibular first molars were included. Inclusion criteria consisted of mature roots with closed apices, absence of carious lesions and resorptions, and root canal curvatures (CC) of 45º<CC<60º. The root canals were prepared using a crown-down pressureless technique. The samples were equally divided into groups A, B, and C based on MAF size: group A: MAF size equivalent to #20; group B: MAF size equivalent to #25, and group C: MAF size equivalent to #30. Cone beam computed tomography was used to evaluate the AT.

Results There were no statistically significant differences in the AT between the canals with different curvature angles up to MAF size #30 (P=0.55).

Conclusion Using flexible hand files for canal preparation, an increase in MAF size up to #30 does not significantly influence AT in severely curved canals.

INTRODUCTION

The aim of root canal treatment is canal disinfection and then sealing the three-dimensional structure of the canal space. Canal preparation is optimally achieved when the mechanical aims have been attained and canal widening and debridement have reached an acceptable level. Avoiding technical errors during canal preparation and prevention of weakening the root canal wall are necessary because they may result in treatment failure (Jafarzadeh and Abbott, 2007a; Givol et al, 2010).

A major concern in the root canal preparation procedure is the canal curvature. A tooth with a straight root or root canal is the exception rather than the normal, since the majority of teeth have roots or root canals with multiple curvatures (Udoye and Jafarzadeh, 2009).

Severe curvatures pose some problems during diagnostic, therapeutic, and prognostic procedures (Jafarzadeh and Abbott, 2007b). In the apical area of curved canals, endodontic instruments tend to remove more dentine on the external side of the curvature, while in the coronal area they remove more dentine on the internal side, i.e. toward the furcation area (Weine et al, 1975). A curvature leads to asymmetrical removal of root dentine, which might result in an increase in the incidence of procedural errors, including apical transportation (AT) (Jafarzadeh and Abbott, 2007b).

The aim of this study was to evaluate the effect of master apical file (MAF) size on the AT in severely curved canals using cone beam computed tomography (CBCT).

METHOD

A total of 250 mandibular first molars were evaluated and 36 teeth were selected to be included in the study. The inclusion criteria were mature roots with closed apices, absence of carious lesions and root resorption, and canal curvatures (CC) of 45º<CC<60º. The canal curvature was measured using the Schneider technique (Schneider, 1971). All of the selected samples were radiographed and the inclusion criteria evaluated. Since the aim of the study was to evaluate the effect of MAF size on the AT of severely curved canals, the samples under study were divided into three groups of A, B, and C (n=12 in each group) based on MAF size:

Group A: MAF size equivalent to #20
Group B: MAF size equivalent to #25
Group C: MAF size equivalent to #30

In each group, 4 teeth with curvature of 45°<CC≤50°; 4 teeth with curvature of 50°<CC≤55°; and 4 teeth with curvature of 55°<CC≤60° were included.

Soft tissue tags and calculus were removed from the root surfaces using a periodontal curette. Then, the samples were immersed in 5.25% sodium hypochlorite for 1 hour for disinfection. A round bur (Dentsply/Maillefer, Tulsa, USA) in a high-speed handpiece was used to create three separate and distinct points on the crown of each sample for precise superimposition of CBCT images in the sagittal cross-section before access cavity preparation and after completion of canal preparation for evaluation of the extent of AT. Then, each four teeth were vertically placed within a plastic impression tray filled with putty impression material (with negligible radiopacity) for the taking of CBCT images. After preparation of each canal, it was placed in the same position as before.

The teeth were scanned with a Planmeca Promax 3D CBCT unit (Planmeca OY, Helsinki, Finland), which has voxel size in high-resolution mode of 160 µm. The machine had the capacity to produce 1-mm-thick sections with a spatial resolution of 3.2 line pairs. The images had a higher resolution with an increase in the number of these line pairs.

After the initial scanning procedures were completed, all the trays along with the samples within them were immersed in normal saline until the canal preparation stage. At first, a fissure bur (Dentsply/Maillefer, Tulsa, USA) was used to achieve a straight-line access. The teeth which did not engage a #15 K-Flex file (Dentsply Maillefer) in their apical constriction at this stage were excluded from the study and were replaced with other samples. Once the access cavity was completed, K-Flex files (Dentsply Maillefer) were used to prepare the canals using a crown-down pressure-less technique. The working length was set at 0.5 mm from the terminus. All the files were pre-curved before use to preserve the canal curvature. After each file, the canals were irrigated with 1 mL of 2.5% sodium hypochlorite.

During canal preparation, each file was completely coated with RC Prep (Premier Dental Products, Plymouth Meeting, PA, USA). Canal patency was confirmed by using a #10 K-Flex file (Dentsply Maillefer). After preparation of canals up to the pre-determined MAF size (#20, #25, or #30) each canal was irrigated with 3 mL of 17% EDTA for 30 seconds, followed by irrigation with normal saline solution. The canals were finally dried with paper points (Ariadent Co, Tehran, Iran). Since the quality of CBCT images decrease after the canals have been obturated with radiopaque materials such as gutta-percha (White and Pharoah, 2009), the second scans were made after canal preparation and making sure that #20, #25, and #30 gutta-percha points fitted the apical parts of the canals. All procedures were performed by a single practitioner.

In order to superimpose the primary and final CBCT images, a sagittal cross-section was provided from the initial image of each sample (Fig. 1). The terminal part of the canal had to be clearly visible on the cross-section. After provision of an appropriate cross-section, the distances of the three points, explained previously, from the sagittal axis on the axial cross-section were measured using the CBCT software program. The distances were recorded for each sample. In the final image of each sample, the distances of the axis from the three points were used to draw the sagittal axis on the axial cross-section and based on this axis the appropriate sagittal cross-section was determined. Therefore, sagittal cross-sections for each sample were provided from one location as far as possible (Fig. 2).

The images scanned by CBCT before and after canal preparation were exported in JPEG format with a high contrast and appropriate colour in order to determine the terminal part of the canal before access cavity preparation and after canal preparation. The images were superimposed with the use of the three distinct points in CS5 Photoshop software. Then, the distances were precisely measured using the same software program in one hundredths of a millimetre. The images were exported to AutoCAD 2010 software to ensure measurement accuracy. A distinct unit needed to be defined for distances in order to convert data into accurate and real units, which was carried out on one of the samples using a caliper by measuring the dimensions of the samples and defined for the software program. Data were analyzed with one-way and two-way ANOVA and a post hoc Tukey test using SPSS 11 software.

RESULTS

The AT effect was seen in all canals prepared with different sizes of the MAF; however, there were no significant differences in AT with different MAF sizes (P=0.55). The maximum and minimum AT were observed with MAF #30 (1.46 mm) and MAF #20 (0.11 mm), respectively. There were no significant differences in AT with different canal curvature; however, with greater canal curvatures the mean of the AT was greater (P=0.52 for 45º<CC≤50º, P=0.94 for 50º<CC≤55º, and P=0.68 for 55º<CC<60º) (Table 1).

Also, within one MAF size, the increasing degree of curvature led to no significant transportation; however, with greater canal curvature the means of the AT were greater (P=0.16 for MAF=20, P=0.11 for MAF=25, and P=0.25 for MAF=30).

DISCUSSION

An important problem in root canal treatment of severely curved canals is the difficulty to continuously follow the canal curvature, which may result in errors such as AT (Jafarzadeh and Abbott, 2007a). The aim of this *in vitro* study was to evaluate the effect of MAF size on the extent of AT in severely curved canals. The results showed that increase in the size of MAF up to #30 does not significantly influence the AT. This means that concluding apical preparation of severely curved canals with MAF #20, #25, or #30 results in similar AT, so it can be proposed that the MAF size in these canals be increased to #30. Also, there was no significant difference in AT with different canal curvatures, so a MAF#30 can be considered up to 60° curvature. Within one MAF size, the increasing degree of curvature led to no significant transportation, so even at MAF #30, it is not especially important how great the curvature is.

This study, in common with others, has some limitations and weaknesses. One of the most important was in selection of severely curved canals. Some researchers (Hamasha et al, 2002; Malcic et al, 2006) believe that a root has dilaceration if there is a ≥90° angle along the root axis, whereas Chohayeb (1983) defined it as a deviation from the normal axis of the tooth of ≥20° in the apical portion. In this study, CC was considered to be 45-60º. This was based on the recent study of Dastmalchi et al, (2011) which showed that most Diplomates of the American Board of Endodontics believe that a dilacerated canal should have a curvature >40°.

Another concern regarding this study was the use of the Schneider technique for determination of canal curvature. Although broadly used, its major drawback is that it mainly emphasizes canal curvature in the coronal region. Some teeth

Table 1. The relationship between canal curvature and apical transportation

Canal curvature	Apical transportation (mm)											
	Mean			Standard deviation			Minimum			Maximum		
	20	25	30	20	25	30	20	25	30	20	25	30
45°<CC≤50°	0.21	0.26	0.322	0.03	0.15	0.15	0.19	0.11	0.16	0.26	0.47	0.52
50°<CC≤55°	0.30	0.31	0.34	0.17	0.20	0.10	0.11	0.14	0.27	0.41	0.6	0.46
55°<CC≤60°	0.46	0.64	0.68	0.21	0.34	0.52	0.19	0.28	0.29	0.55	0.41	1.46
All combined	0.32	0.40	0.45	0.18	0.28	0.33						
	P=0.16	P=0.55	P=0.25	F=2.24	F=2.83	F=1.59						

Figure 1. Sagittal section before and after preparation

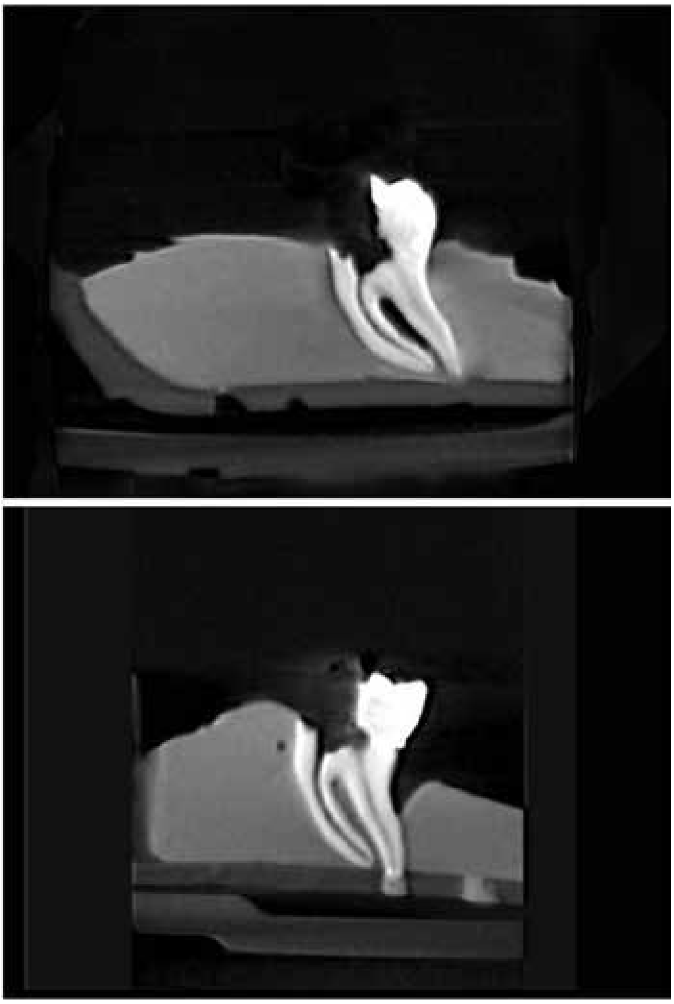
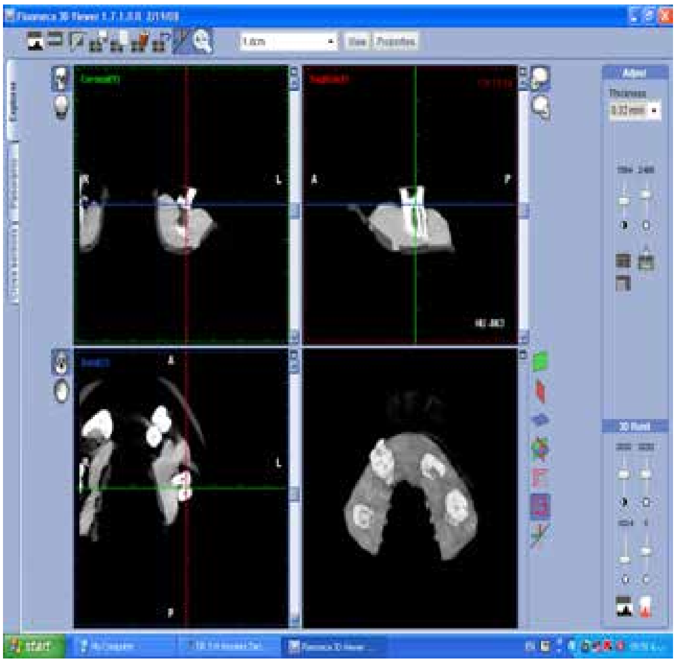


Figure 2. The scanned image in different cross-sections



may have the same Schneider angle but the degree of canal curvature at the apex can be very different. It has been shown that there are significant differences between the curvature angle values determined using Schneider, Weine and Long-Axis techniques which are used for comparing canal curvatures (Günday et al, 2005).

A limitation in this study was finding natural teeth with this curvature. Another consideration was the instrument of choice for canal preparation. Although it may seem that Ni-Ti instruments are the choice, these instruments are not routinely used by endodontists across the world (Qualtrough et al, 1999; Peciuliene et al, 2010; Koch, 2013), so we decided to use K-Flex files for canal preparation. K-files may induce more transportation in severely curved canals (Jafarzadeh and Abbott, 2007b), so K-flex files were used in this study.

AT could be increased by apico-coronal instrumentation techniques. The crown-down technique may be considered the best method for preparing severely curved canals (Dastmalchi et al, 2011). In the present study, the crown-down pressure-less technique was used for canal preparation. Another important point in the canal preparation procedure (especially in curved canals) is straight-line access cavity preparation, because straighter access to the apical foramen would reduce the degree of transportation (Hargreaves and Cohen, 2011).

In the present study, CBCT was used to evaluate the extent of AT, consistent with studies carried out by Hartmann et al, (2007) and Oliviera et al, (2009); the only difference was the fact that in the present study sagittal cross-sections were used to evaluate AT. Axial cross-sections were not used because in these cross-sections no images are visible from a distance of 2 mm from the apical end toward the apex, and none of the previous studies have presented images from these cross-sections; they have presented images 2 mm coronal to the apex. However, AT usually occurs at this location at a distance of 0.5-1.5 mm from the apex. This area is a critical point in root canal treatment; therefore, sagittal cross-sections were used to avoid false negative results.

The majority of previous studies (Lopes et al, 1998; Jardin and Gulabivala, 2000; Hartmann et al, 2007; Oliviera et al, 2009; Ozer, 2011, Zarei et al, 2011) have evaluated and compared various techniques and instruments used for canal preparation and obturation; such studies usually have not evaluated the effect of instrument size and various canal curvatures (similar to the severity in the present study) on the extent of AT. Therefore, it is not possible to compare the results of the present study with those of previous workers. Ours might be considered pioneering because no similar published study is available on severe canal curvatures. It is recommended that the radius of curvature be considered as a variable in the future studies. Considering a larger sample size, using Ni-Ti files and K-files for canal preparation, and using other techniques for evaluating the AT would also be helpful in the future studies. These studies would help practitioners to better manage severely curved canals.

CONCLUSION

In this *in vitro* experiment using hand files an increase in the size of MAF up to #30 did not significantly influence apical transportation.

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