Apical Transportation: A Comparative Evaluation of Three Root Canal Instrumentation Techniques with Three Different Apical Diameters

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Abstract

This study conducted an *in vitro* analysis of the level of apical transportation in mesiobuccal roots of upper molars after manual instrumentation with stainless steel files, preparation with the K3 system, and with a reciprocating NSK handpiece. Sixty roots were mounted in muffles and then longitudinally sectioned. A digital image was acquired of the inner surface of one root half. After instrumentation, the inner surfaces of the same root halves were digitized with file sizes #30, #35, and #40. Each image obtained was superimposed over the corresponding preoperative image, and the apical transportation was measured. The Friedman and Wilcoxon tests were used to compare results for the file sizes, and comparison of the groups was made with the Kruskal-Wallis test, demonstrating statistically significant differences ($P = .000$). The stainless steel file sizes #35 and #40 caused significant apical transportation, and K3 system proved safe for apical preparation, with little deviation. *(J Endod 2008;34:1545–1548)*

Key Words

Dental pulp cavity, endodontics, root canal preparation

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In the general context of endodontic treatment, root canal preparation is of particular importance because it has a direct impact on cleaning and shaping. There is a constant search for ever better performance, in terms of the quantity of material removed from the root wall and of faithful adherence to the original shape of the root canal, by means of improving techniques and instruments.

In teeth with periapical lesions where there is greater bacterial propagation in dentin tubules, some authors propose a larger apical diameter (1–5), with the objective of improving cleanliness and disinfection. However, where there are curved and flattened canals, as with the mesiobuccal roots of upper molars and the mesial roots of the lower molars, this widening can lead to undesirable occurrences.

For a long time, a size #30 master apical file was considered to be ideal for studies such as this, because it was believed to provide adequate cleaning of the apical region, even in cases in which there was microbial activity, while still following the root canal curvature because of its flexibility (2, 6–9). However, the new fashion for wider apical preparation, with up to size #35 and #40 files, involves increasing loss of flexibility, which results in greater canal displacement, particularly with stainless steel files.

The objective of this study was to carry out an *in vitro* assessment of the occurrence and magnitude of apical transportation in the mesiobuccal roots of upper molars after instrumentation with 3 different apical diameters by using manual stainless steel files, the K3 system with continuous rotation, and a reciprocating NSK handpiece.

Material and Methods

This study was approved by the Research Ethics Committee at the Federal University of Rio Grande do Sul, Brazil (No. 196/06).

Sixty extracted human maxillary molars were radiographed in the buccal-palatal direction. Teeth were excluded from the study if they exhibited previous endodontic manipulation, incomplete root formation, calcification, internal or external resorption, or curvature greater than 40 degrees.

The crowns were sectioned 5 mm below the cementoenamel junction, and the mesiobuccal root was separated from the others. The canals were irrigated with 1% sodium hypochlorite and accessed by using a size #10 Triple-Flex file (SybronEndo, Glendora, CA). Working length was defined by subtracting 1 mm from the point at which the file tip was protruded from the apical foramen.

With the file in the canal, 2 lines were drawn on the outside of the root, one mesial and one distal, connecting the point at which the file entered the root canal and the point it came out through the apical foramen to indicate where the sagittal section should be made.

The roots were mounted in a modified version of the muffle proposed by Bramante et al. (10). After mounting, the blocks of resin containing the roots were removed from their muffles and cut lengthwise along the line drawn previously by using a diamond disk mounted on a precision cutting machine (Extec Labcut 1010, Enfield, CT).

Before roots were prepared, the halves were examined, and the one with the clearest root path was selected and identified. A size #10 file was inserted into this half up to working length and fixed with wax. Then a digital image was taken of it by using an HP Photosmart 2600/2700 All-in-One scanner (Hewlett-Packard Development Com-

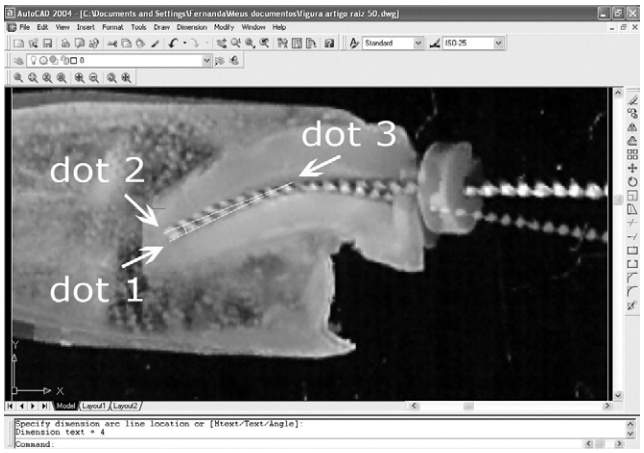

Figure 1. Superimposed images with measurements in AutoCad.

pany, Palo Alto, CA) and saved in an 8-bit JPEG file at 300 dpi and real size, with automatic brightness and contrast adjustment.

Root canal curvatures were determined mathematically by means of measurement of angle and radius (11). The mean angle of curvature varied from 15–40 degrees. An equal number of roots with similar degrees of curvature and radius were distributed at random into 3 groups. The resulting buccal and palatal sections were replaced in their molds in exactly the same position as before.

In all 3 groups, apical preparation was carried out with size #30, #35, and #40 instruments in turn. After size #30 instrument had been used, the same half of each root was once more digitized as previously, with a size #30 file inserted up to working length. These steps were repeated for size #35 and #40 files until apical stop preparation was complete.

After each instrument change, canals were irrigated with 2 mL of 1% sodium hypochlorite and 17% trisodium ethylenediaminetetraacetic acid alternately, and recapitulation was performed with a size #10 stainless steel file up to working length. Each instrument was used to prepare 3 root canals and was then disposed of.

Group 1

Twenty roots were prepared crown-down by using Triple Flex manual files (SybronEndo), starting with a size #45 or #40 file and using balanced force movements. This step was repeated with instruments of successively smaller sizes until working length was reached.

Files used in the apical third of the root canal had their last few millimeters precurved by using an endodontic file bender (Flexobend, Aronson, SP, Brazil). Soon after, a step-back procedure was performed by using size #45, #50, #55, and #60 files with anticurvature filing motions.

Group 2

Twenty roots were instrumented by using the K3 system (SybronEndo) at a speed of 300 rpm and with torque set to 2 N.

The cervical third was prepared by using #25/.10 and #25/.08 orifice shapers, the mid-third was prepared with #30/.06 and #25/.04 files, and the apical third was prepared by using the sequence #30/.02, #35/.02, and #40/.02.

Group 3

Twenty roots were instrumented by using a reciprocating (NSK) handpiece and Triple Flex stainless steel files (SybronEndo). The technique used was to introduce the largest size file (size #45, #40) until meeting traction and resistance to anticurvature filing motions. Progressively smaller instruments were then used until working length was reached.

Files used in the apical third of the root canals had their last few millimeters precurved. After the apical stop had been prepared, a step-back was performed (4 instruments with sizes greater than the final apical file).

Adobe Photoshop (Adobe Systems, Inc, San Jose, CA) was then used to transform each image showing a size #30, #35, or #40 file to 50% transparency and to superimpose each one separately onto its preoperative image. Small translation and rotation movements were used to achieve a perfect fit between its outline and the background image.

Superimposed images were then marked with 3 dots: dot 1, apical end of file #10; dot 2, apical end of final apical file (#30, #35, and #40); and dot 3, site at which the instrumented canal began to deviate from the anatomic canal. This image was then transferred to AutoCAD 2000 (Autodesk Incorporated, San Rafael, CA), which was used to draw and measure the angle formed by the lines that joined dot 1 to dot 3 and dot 2 to dot 3 (Fig. 1).

The Friedman and Wilcoxon nonparametric tests were used for comparisons between files, and the Kruskal-Wallis test was used to compare the 3 groups. The level of significance adopted was 1%.

TABLE 1. Comparisons between Different Size Files of the Differences (in Degrees) between the Initial Curvature and the Curvature after Preparation, within Each Group

Difference	n	Mean†	Standard Deviation	*P* Value
Manual group* (group 1)				
Difference with size #30 file	20	0.00	0.00	
Difference with size #35 file	20	1.10^{A}	0.97	.000
Difference with size #40 file	20	3.20^{B}	1.28	
K3 group* (group 2)				
Difference with size #30 file	20	0.00	0.00	
Difference with size #35 file	20	0.10^{A}	0.31	.000
Difference with size #40 file	20	1.00^{B}	0.97	
NSK group (group 3)				
Difference with size #30 file	20	0.35^{A}	0.49	
Difference with size #35 file	20	1.95^{B}	1.23	.000
Difference with size #40 file	20	4.60^{C}	3.17	

*The #30 K3 and manual files were not included in the statistical test because none of the roots exhibited any difference between initial and prepared curvature.

†Values followed by the same superscript letter do not differ.