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An *In Vivo* Evaluation of Two Types of Files used to Accurately Determine the Diameter of the Apical Constriction of a Root Canal: An *In Vivo* Study

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Abstract

Aim: The aim of this study was to compare sizes of the first instrument with or without a taper that binds at the apical constriction of a root canal after coronal flaring.

Methods and Materials: A total of 310 canals were evaluated in patients presenting for root canal therapy. Canals with intact apices were selected. After gaining straight line endodontic access, the coronal third was flared using Gates-Glidden drills. Working length was determined using an apex locator. ISO Standard K-files (tapered) were passively introduced into the canals starting with a No. 15 file. The first K-file size to bind against the canal walls without pushing and to reach the working length was recorded as the FKFB (First K File to Bind). Next, ISO Standard Lightspeed files (non-tapered instruments) starting with No. 20 were then gently introduced by hand to each canal in ascending order to the working length. The first size of a Lightspeed instrument to bind against the canal walls and reach the working length was recorded as FLSB (First Light Speed to Bind). In all instances a larger file was introduced to ensure it could not reach the same depth (i.e., working length). Statistical analysis was carried out using a univariate analysis of variance (ANOVA).

Results: The average size of the FLSB to bind against the canal walls first at the working length was approximately two ISO sizes larger than the FKFB ($P<0.001$).

Conclusion: The clinician should consider introducing a non-tapered instrument to working length after coronal

flaring because determination of the initial narrow apical canal diameter plays a major factor in identifying the extent of final apical shaping. Because the first non-tapered instrument that binds the apical constriction is larger than the corresponding tapered instrument, it better reflects the actual narrow apical diameter of the canal.

Clinical Significance: The initiation of canal instrumentation with a K-file size three sizes beyond the mean values of the FLSB will result in greater final enlargement of the canal compared to starting with the FKFB. This increased canal enlargement facilitates improved mechanical and chemical cleansing of the root canal ensuring removal of more microorganisms and their substrates, thus, improving the outcome of the treatment.

Keywords: Apical width, working length, Lightspeed, apical constriction

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Introduction

A primary concern in endodontic therapy is to mechanically and chemically clean the root canal system thoroughly to remove microorganisms and their substrates from the canal. The vertical dimension of the root canal and the importance of the precise determination of the working length are the focus of most textbooks and much of the literature.[1,2] Different methods for working length determination have also been described.[3] Literature on canal instrumentation in terms of filing, reaming, and techniques for instrumentation usage always stress the importance of enlarging the canal size.[4] However, due to the lack of solid scientific evidence a question remains as to how large is large enough to maximize the potential for a successful outcome.

Haga[5] found mechanical enlargement of the root canal to a size two sizes larger than the original canal size was still inadequate. In histological sections bacteria were found in the dentinal tubules. As a result, enlarging the apical portion of the root canal to three sizes larger than the first file to bind has been recommended.[6,7] The rationale behind this approach is the first file to bind reflects the diameter of the apical canal. By using three successively larger files to the same working length, the layer of heavily infected dentin should be removed from all regions of the apical canal wall. Another reason for this canal preparation strategy is to create an apical stop (apical matrix) designed to reduce apical leakage and extrusion of filling material beyond the apical foramen. However, there is no evidence the instrument that binds first actually reflects the diameter of the canal in the apical region. Thus, the concept of widening the apical canal to three sizes larger than the first file to bind is not based on evidence. Gutierrez and Garcia[8] showed canals are often improperly cleaned. They attributed inadequate instrumentation to the root canal diameter being larger than the instrument size used for calibration of the initial canal size in each individual case. This finding suggests each canal should be calibrated independently before instrumentation so proper preparation can be achieved.

The selection of the first instrument to fit the apical constriction is achieved by tactile sensation, which is possible only after coronal flaring. Any tapering discrepancy between the

gauging instrument and the canal may lead to early instrumentation of the canal wall, causing a false sensation of apical binding. Instruments with a large taper might give a resistance sensation if it comes in contact with the canal walls in the coronal portion of the canal without any contact between the instrument and the canal walls in the more critical apical portion of the canal.

Thus, the aim of the present *in vivo* study was to compare sizes of the first instrument with or without a taper that binds at the apical constriction of a root canal after coronal flaring.

Methods and Materials

The present study consisted of 310 root canals from among teeth randomly selected by two different evaluators in patients with intact root apices who presented for endodontic therapy at the Department of Endodontics, Sharad Pawar Dental College and Hospital in Sawangi (M), Wardha, India. The selected teeth for the study were grouped according to tooth type as shown in Table 1.

A standard endodontic access cavity was prepared using an Endo Access kit (Dentsply Mallifer, Switzerland). The coronal third was flared using a Gates Glidden drill (Dentsply Mallifer, Switzerland), beginning with size 1 at the orifice followed by sizes 2 and 3. Apical patency was established by passing a K-file (Dentsply, Mallifer, Switzerland) size 10 through the foramen, and the working length was determined using an apex locator {Root ZX (J Mortia, Tokyo, Japan)}.

Standardized tapered K-file hand instruments were gently introduced by the first evaluator to the working length beginning with size 15. The first K-file to bind against the canal walls without

Table 1. Study teeth grouped according to tooth type.

Teeth	Abbreviation	Description
Maxillary	I	Central and lateral incisors.
	C	Canines.
	Pm-1ca	Premolars with one canal.
	Pm-2ca	Premolars with two canals.
	M-p	Molars–palatal roots.
	M-b	Molars–buccal roots.
Mandibular	I	Central and lateral incisors.
	C	Canines.
	Pm-1ca	Premolars with one canal.
	Pm-2ca	Premolars with two canals.
	M-d	Molars–distal root.
	M-m	Molars–mesial root.

pushing while reaching the working length was recorded as the "First K File to Bind" (FKFB). The same procedure was repeated by the second evaluator.

Next, Lightspeed non-tapered instruments (Lightspeed Technology, San Antonio, TX, USA) were gently introduced into each canal by hand in ascending order beginning with size 20 to the working length. The first Lightspeed instrument to bind against the canal walls while reaching the working length was recorded as the "First Light Speed to Bind" (FLSB). This step was also performed by a second evaluator.

In all instances a larger file was introduced to ensure it could not reach the same depth (i.e., working length). A univariate analysis of variance (ANOVA) was performed using SPSS version 14.0 statistical software (SPSS Inc., Chicago, IL, USA).

Results

The mean ISO sizes of the diameter of the root canals as measured by tapered or non-tapered instruments are shown in Figures 1, 2, and 3. The average size of the FLSB was approximately two ISO sizes larger than the average size of the FKFB ($P < 0.001$). The mean diameters of the FKFB and the FLSB in all root canal groups, after coronal flaring, was 23.23 and 33.31 ($P < 0.001$), respectively.

Discussion

The aim of root canal preparation is to enlarge the apical portion of a root canal enough for the following:

- Placement and replacement of the irrigation solution[9]
- Placement of an intracanal dressing
- To facilitate obturation procedures

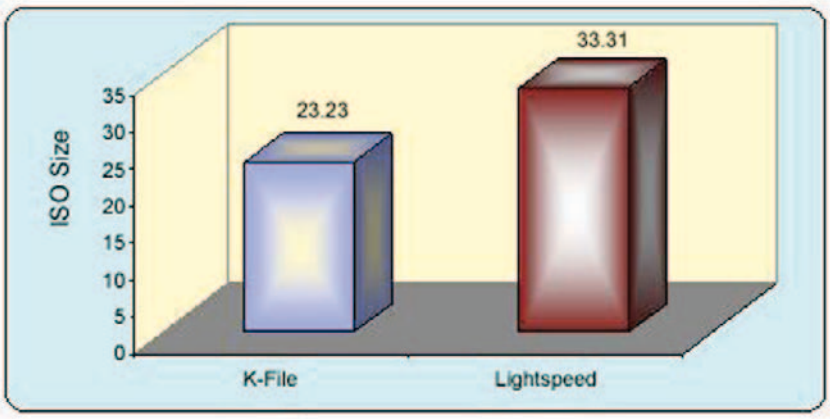

Figure 1. The average size of the FLSB was approximately two ISO sizes larger than the average size of the FKFB ($P < 0.001$).

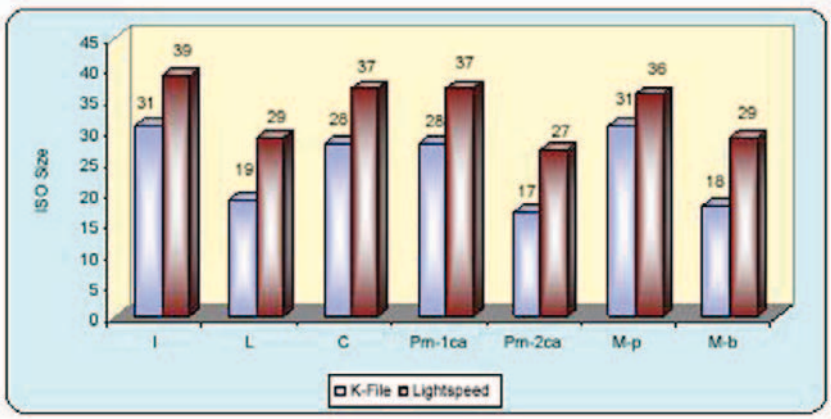

Figure 2. The mean diameter of the FKFB was 24.57 and the FLSB was 33.42.

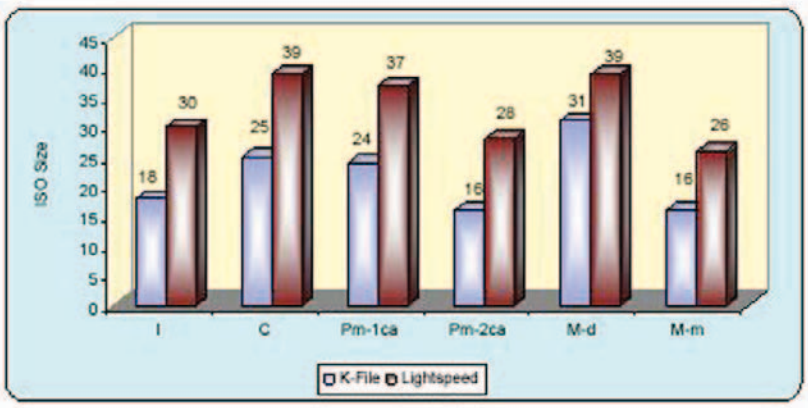

Figure 3. The mean diameter of the FKFB was 21.66 and the FLSB was 33.16.

On the other hand, it should not be so large that it unnecessarily weakens the root and increases the risk of fracture.

Clinicians typically select a 0.02 tapered instrument such as a K-type file to gauge the original canal width (apical constriction) following coronal flaring and determination of the working length. Using this information the decision is made regarding the extent of apical shaping and final apical canal enlargement needed for a successful root canal filling. The present study suggests this time honored strategy is often incorrect.

Coronal interferences and root canal curvatures complicate the clinician's ability to accurately sense the true apical diameter with using a tapered file. Premature contacts of the file against the canal walls interfere with its progression toward the apex. Early flaring of the coronal third, regardless of the method of instrumentation used, removes these contacts, opens the space, and reduces unwanted file contact. As suggested by Leeb[10], the file progresses more easily toward the apex after flaring. Moreover, pre-flaring improves the tactile feel of the instrument and allows the operator to better sense the canal size near the apex without interferences from curvatures and irregularities.[11,12] Pre-flaring can be accomplished by either manual (K-files) or mechanical instrumentation (rotary flaring, Gates Glidden drills, or NiTi rotary instruments).

The present study clearly suggests the FLSB can be significantly larger than the FKFB in all canals studied even after coronal flaring. This information indicates canal interferences and curvatures are factors in a clinician's ability to accurately sense the true apical diameter with a tapered file. This is likely due to binding of the coronal portion, rather than the tip, of a tapered K-file against the canal walls because it has a larger coronal diameter. Therefore, a tapered K-file that binds may not bind at the working length. Thus, the use of a non-tapered endodontic instrument such as the Lightspeed, which has the largest diameter at its tip, is a better choice as the initial instrument used to determine the original canal size due to its more accurate adaptation to the canal walls in the apical area of the canal. Moreover, Lightspeed instruments follow the canal curvature better than K-files because of their greater flexibility.[13] In addition, contact between the lightspeed instrument and the canal wall occurs only in the apical 2-3 mm of the the root canal, thus, enabling better apical adaptation.

The differences between the FKFB and the FLSB was largely found in more narrow and curved root canals such as in the mesial canals of mandibular molars or in the canals of mandibular incisors. Differences were less prominent in wide and relatively straight canals such as in central incisors, the distal roots of mandibular molars, or in the palatal canal of maxillary molars.

The apical minor diameter, or minor constriction, is best visualized by studying cross-sections of apical canals as described by Wu et al.[14] In his classic study he demonstrated the average initial narrow diameter at the apical constriction ranges from 0.3 to 0.4 mm. In the present study

the mean initial apical narrow diameter in all root canals was 0.34 mm which is consistent with those in the Wu study.

Conclusion

The clinician should consider introducing a non-tapered instrument to working length after coronal flaring because determination of the initial narrow apical canal diameter plays a major factor in identifying the extent of final apical shaping. Because the first non-tapered instrument that binds the apical constriction is larger than the corresponding tapered instrument, it better reflects the actual narrow apical diameter of the canal.

Clinical Significance

The initiation of canal instrumentation with a K-file size three sizes beyond the mean values of the FLSB will result in greater final enlargement of the canal compared to starting with the FKFB. This increased canal enlargement facilitates improved mechanical and chemical cleansing of the root canal ensuring removal of more microorganisms and their substrates, thus, improving the outcome of the treatment.

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