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The Accuracy of the Root ZX Electronic Apex Locator Using Stainless-Steel and Nickel-Titanium Files

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Numerous apex locator studies have been performed. Generally, they use only stainless-steel hand files for testing purposes. Today many clinicians use both stainless-steel and nickel-titanium files during the treatment of a case. Given the widespread use of nickel-titanium files, a comparison of the accuracy in determining length with an apex locator using stainless-steel and nickel-titanium files seems clinically relevant. Campbell et al. (1) published a study where only nickel-titanium files were used. A literature search failed to reveal any studies that directly compared stainless-steel and nickel-titanium files when used with an apex locator to determine length measurements in the same tooth. The purpose of this study was to determine if there is a measurable difference in accuracy of length determination when stainless-steel and nickel-titanium files were used for this purpose in the same tooth.

MATERIALS AND METHODS

A group of 20, single-rooted, single-canal, extracted, maxillary anterior teeth with mature root apices and patent root canals were used. Tooth suitability was determined by visual inspection using a dental operating microscope, radiographs, and finally, after decoronation, placement of a file into the root canal to determine patency. Each tooth was decoronated at approximately the CEJ to provide a flat horizontal surface. A #10 stainless-steel Flexofile (Dentsply/Maillefer, Tulsa, OK) was placed into the root canal until the tip of the file reached the plane of the major diameter of the foramen as defined by Kuttler (2). Proper positioning was verified using a dental operating microscope (Global, St. Louis, MO) at the 0.8 step (×6.4 magnification) setting to view the file tip. The file length was determined by placing the file's measurement stopper flush to the flat horizontal coronal surface of the root when the file tip was placed to the level of the major foramen. The length of the file was then read using a traveling microscope (Gartner Scientific Instruments, Chicago, IL) with a measurement accuracy of 0.01 mm. The Endo-M-Block (Dentsply/Maillefer) was used to hold the file in a horizontal position when it was being measured with the traveling microscope.

Canal measurements were made to the nearest 0.01 mm. All experimental measurements were repeated three times. An individual tooth's true length was taken to be the average of these measurements. Each tooth was mounted in an alginate model (3) so that an electronic apex locator could be used to measure canal length. The manufacturer's recommended operating procedures for the Root ZX (J Morita USA, Inc., Irvine, CA) apex locator were used.

Before taking electronic apex measurements, the root canals required instrumentation to an ISO size #20 file to allow the measurement files to fit to length. All measurements of canal length were to the apex designation on the Root ZX or the apex location as visualized with the dental operating microscope. The four file types tested were stainless-steel hand Flexofiles (FO) (Dentsply/Maillefer), nickel-titanium hand Sureflex (SF) files (Dentsply/Caulk, Milford, DE), nickel-titanium rotary Lightspeed files (LS) (Lightspeed Technologies Inc., San Antonio, TX) and nickel-titanium rotary Profile .04 taper (PF) files (Dentsply/Tulsa Dental, Tulsa, OK). To avoid bias, the measurements were taken by randomizing the order of the file types, with the exception that the Profile rotary was always used last because it incorporated the greatest amount of taper and therefore required additional removal of dentin to be placed to the apex for all measurements. Files with apical sizes of #20, #25, and #30 were used for all file groups.

The instrumentation technique consisted of a simple crown-down technique as described by Stabholtz et al. (4), when Gates Glidden rotary instruments were used for preflaring the coronal ⅓ of canal followed by stainless-steel files #20, #25, and #30 to the apex. Data for each tooth, file type, and file size were recorded along with the true length (TL) and electronically measured length (EL). One operator performed the TL and EL measurements and all the canal instrumentation. A random-effects, repeated-measures ANOVA was used to assess whether there is a different accuracy according to: file type (FO, SF, PF, LS) and file size (#20, #25, and #30). Accuracy was defined as the difference between the TL and the EL.

RESULTS

As the tooth-to-tooth variability accounted for 99.83% of all variability, measurement of the TL accounts for less than 0.17% of error. The ANOVA results showed significant difference between the 12 groups of file types and file sizes ($F(30, 689) = 39.6$, $p < 0.0001$). Statistically significant differences occurred between file types and sizes but the largest of these differences (0.11 mm) was not clinically significant. Overall variability between electronic measurements and true length was approximately 6% regardless of

type or size of file used. It seems that these files may be used interchangeably during the course of root canal therapy without compromising the working length.

DISCUSSION

Statistical analysis indicated that the TL measurements in this study were accurate. Measurement difference was attributed primarily to the different teeth and not to the measurement technique. True length measurements also were in close agreement with the measurements obtained using the Root ZX electronic apex locator. Only the size #20 LS file consistently had an EL shorter than the TL. All other file types and sizes were within measurement error. Analysis indicated smaller files tended to give lower than actual TL readings, whereas larger file size tended to give higher than actual TL readings. When considering positive and negative EL measurements, on average all measurements were within ± 0.11 mm of the true length. This difference was statistically significant. This difference does not seem to be attributed to the measurement process but rather to the different file types and sizes. This difference of approximately 0.11 mm seems clinically insignificant. There was variability in file measurements with the difference between EL and TL exceeding 0.5 mm only 6% of the time regardless of the type or size of the file used. It seems that using the Root ZX with the various file types used in this study would be accurate within ± 0.11 mm, assuming that the apex locator is recalibrated with each file size according to the manufacturer's instructions. It is useful to know that files may be used interchangeably during the course of root canal therapy without compromising the working length. If the EL measurement is used and the working length is arbitrarily established 1-mm short of the EL apex reading, then instrumentation beyond the apical foramen should be avoided successfully. Because larger files were not used it is difficult to extrapolate what differences, if any, may occur with their use for length determination. Previous research (5) has demonstrated that larger file sizes tend to increase error in measurement accuracy, especially when one considers the need to instrument to the greater foramen to perform a "true" measurement as described in "materials and methods." This may be a mute point because most clinicians traditionally establish a working length measurement with files smaller than size #35.

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