An *In Vivo* Comparison of the Root ZX II, the Apex NRG XFR, and Mini Apex Locator by Using Rotary Nickel-Titanium Files

Chris Siu, DDS, BSc, J. Gordon Marshall, DMD, and J. Craig Baumgartner, DDS, PhD

Abstract

Introduction: The purpose of this study was to compare the accuracy of working length (WL) measurements by using the Root ZX II, Apex NRG XFR, and Mini Apex Locator with rotary nickel-titanium (NiTi) instruments. **Methods:** Twenty-eight teeth had their WLs determined with each electronic apex locator (EAL) by using 0.04 taper ProFiles sizes 40–20 in a crown-down technique until WL was reached. Four control teeth had their WL determined by using stainless steel hand files. The files were cemented at WL, and the teeth were extracted. The apical 4 mm of each root was shaved to the apical constriction, exposing the file. Photographs were taken under 15× and 30× magnification and projected at 360× and 720× for evaluation. **Results:** The accuracy of the Root ZX II, Apex NRG XFR, and Mini Apex Locator in locating the minor diameter within ±0.5 mm was 50%, 46.43%, and 39.29%, respectively. There was no statistically significant difference between the EALs in locating the minor diameter. The determination of WL by using hand files in the control teeth was more accurate. **Conclusions:** The Root ZX II, Apex NRG XFR, and Mini Apex Locator used with rotary NiTi files were able to locate the apical constriction within ±0.5 mm only 50% or less of the time. *(J Endod 2009;35:962–965)*

Key Words

Apex NRG ZFR, apical constriction, electronic apex locator, Mini Apex Locator, minor diameter, Root ZX II, rotary files, working length

From the Department of Endodontology, School of Dentistry, Oregon Health and Science University, Portland, Oregon.

Address requests for reprints to J. Craig Baumgartner, DDS, PhD, Department of Endodontology, OHSU School of Dentistry, Portland, OR 97239. E-mail address: baumgarc@ohsu.edu.

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The success of root canal therapy is dependent on establishing a correct working length (WL). WL is defined as the distance from a coronal reference point to the point at which canal preparation and obturation should terminate (1). It has been stated that WL should be established at the minor diameter (or apical constriction) of the root (2). Its position typically is near the cementodentinal junction, where the pulpal tissues transition to the periodontal tissues (3, 4).

Methods of determining WL include using radiographs, tactile sensation, and electronic apex locators (EALs). Microscopic studies have shown that the minor diameter is located 0.5–0.75 mm coronal to the major diameter, which in turn is located about 0.5 mm coronal to the apical terminus (5, 6). As a result, WL determined from radiographs is generally measured about 0.5–1 mm short of the radiographic apex. Pratten and McDonald (7) showed that the assumption of the apical constriction being 1 mm short of the radiographic apex will result in an underestimation of WL. Williams et al (8) found that when a file looks short radiographically compared with the radiographic apex, it is actually closer to the major foramen than it appears. When a file looks long radiographically compared with the radiographic apex, the file is farther from the major foramen than it appears. Vertical and horizontal cone angulations, film processing issues, tooth inclination, and film position will influence WL determination from radiographs (9). Furthermore, identification of the radiographic apex of some teeth might be difficult as a result of superimposition of bony structures such as the zygomatic arch (10).

An endodontic file can be used to manually feel the location of the apical constriction. However, tactile sense is quite variable, and accuracy is questionable (11, 12). Root canals with excessive curvature, an immature apex, or calcified canals will hinder the tactile sensation of the apical constriction (13).

EALs alert the dental practitioner on its display and/or through audible sounds when an endodontic file reaches the apical constriction. Many studies have shown that current EALs are quite accurate (14–20). Pratten and McDonald (7) found that apex locators were more accurate than radiographs in determining the apical constriction. Hassanien et al (21) found that radiographic determination of the WL 0.5 mm short of the radiographic apex was closer to the apical constriction than using the Root ZX, but they also found that the EAL was able to locate the file closer to the apical foramen while remaining within the confines of the canal.

Manufacturers of EALs recommend using the largest file that registers a WL reading. Briseño-Marroquín et al (22) studied the accuracy of 4 different EALs with 3 different instrument sizes of hand files. They found that sizes 08, 10, and 15 have no influence on the accuracy of WL determination.

Manufacturers also suggest that canals be moist rather than dry to achieve a more accurate WL reading. Özsezer et al (23) found that the WL measurements with the ProPex (DENTSPLY Maillefer, Ballaigues, Switzerland) were more accurate after extirpation of the pulp than after using irrigation solutions. Among the irrigation solutions, the accuracy of WL determination was highest with chlorhexidine gluconate, followed by sodium hypochlorite and saline.

Several EALs can be used to locate the apical constriction during rotary instrumentation. They are designed to auto-reverse or auto-stop when the file reaches the apical constriction. The accuracy of these units has been studied with mixed results (24–29). Brasseler has recently introduced a rotary handpiece (MPA-F10R 10:1 reduction miniature head) that can be attached to any apex locator. With this handpiece, auto-reverse

or auto-stop is not possible. The prevention of instrumentation past the minor diameter relies on the operator monitoring the EAL readings during instrumentation. The purpose of this study was to compare the accuracy of the Root ZX II with the Low Speed Handpiece module (J. Morita USA, Tustin, CA), Apex NRG XFR (Medic NRG Ltd, Tel Aviv, Israel) attached to the Brasseler handpiece (Brasseler USA, Savannah, GA), and Mini Apex Locator (Sybron Endo, Sybron Dental, Anaheim, CA) attached to the Brasseler handpiece by using rotary nickel-titanium (NiTi) instruments.

Materials and Methods

Seven adult patients with ages ranging from 36–70 years, with teeth treatment planned for extraction at Oregon Health & Science University, participated in this study. Teeth with severe periodontitis or gross caries were excluded from the study. Informed consent was obtained from each patient in accordance with the approval by the Oregon Health & Science University Institutional Review Board. All clinical procedures were performed by the principal investigator. The clinical protocol was similar to that of Welk et al (16). Single canalled maxillary and mandibular incisors, canines, and premolars with completely formed apices confirmed by periapical radiographs were selected for this study. Anesthesia was attained, and a dental dam was placed. If a flat reference point was not available, the cusp tip was reduced by using a 1958 cross-cut carbide bur (Brasseler USA) in a high-speed handpiece. Access to the pulp chamber and the canal was made by using a #4 carbide bur (Brasseler USA). The cervical bulge of dentin was removed by using sizes 2–4 Gates-Glidden drills in a low-speed handpiece, followed by sizes 50–30 NiTi Orifice Shapers (Dentsply Tulsa Dental, Tulsa, OK) in an electric rotary handpiece set at 300 rpm. The canals were irrigated with 0.5 mL of 5.25% sodium hypochlorite solution by using a 27-gauge endodontic needle (Sherwood Medical, St Louis, MO) after the use of each endodontic file. Excess fluid from the pulp chamber was removed, but the canal was not dried.

The Apex NRG XFR and Mini Apex Locator were attached to the Brasseler cordless rotary motor. The file holder of the EAL was attached to the file holder lead of the handpiece. The rotary file was inserted into the handpiece, and the metal clip of the handpiece was latched to the file (Fig. 1). The Root ZX II has its own rotary handpiece called the Low Speed Handpiece module that attaches to the apex locator unit. The file electrode that is built into the handpiece was latched onto the rotary NiTi file. The file rotates automatically when the file enters the canal. The motor was set to automatically stop rotating at the level 0.5 on its display when the apical constriction is reached. Each EAL was used according to manufacturer's instructions. All files were rotated at 300 rpm.

Each canal was instrumented with 0.04 tapered NiTi rotary Profiles sizes 40–20 (Dentsply Tulsa Dental) in a crown-down manner. The sequence of files was repeated if necessary. Once the apical constriction was reached by the first rotary file as indicated by the EAL, the rotary motor was stopped. At this point, the silicon stop was positioned to the coronal reference point, the file was unlatched from the rotary handpiece, the file was removed from the canal, and the length was measured with a digital caliper (Mitutoyo Corp, Tokyo, Japan), recorded to the nearest 0.01 mm. Another rotary file of the same size was used to achieve readings with the other EALs being evaluated in the same canal. No attempt was made to go beyond the apical constriction as indicated by the EAL because our goal was not to instrument past the apical constriction. The order of the EALs was randomly chosen.

The file used with the first EAL had the silicon stop fixed to the shaft with cyanoacrylate and was cemented in place at WL by using glass ionomer cement (3 M ESPE, St Paul, MN). The cement was allowed to set for at least 5 minutes, and the tooth was extracted. The tooth was then placed in 5.25% sodium hypochlorite for 15 minutes to remove any remaining organic tissue from the root and then stored in a 0.2% thymol solution.

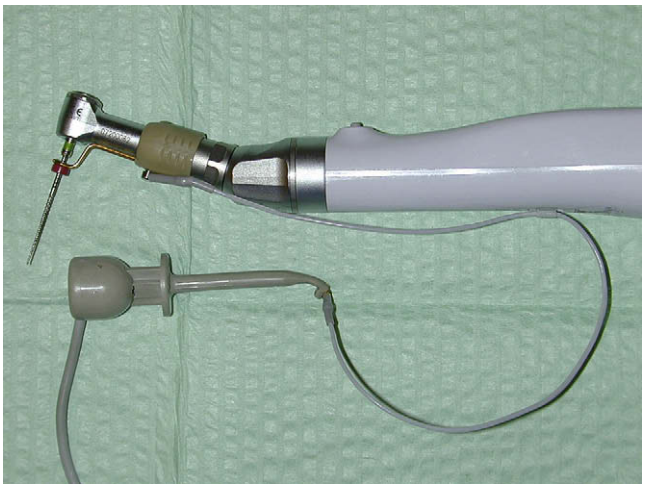

Figure 1. The Brasseler MPA-F10R 10:1 reduction miniature head handpiece attached to the file holder of an EAL.

Four other canals had their WLs determined with each EAL by using 0.02 tapered stainless steel hand K-files without the handpiece attachment for comparison purposes (controls). The largest file to register WL following manufacturer's instructions was used. The file had its stop fixed to the shaft with cyanoacrylate at WL. The file was then cemented into the tooth at WL with glass ionomer, and the tooth was extracted.

All teeth were radiographed in the mesiodistal and buccolingual planes at an object film distance of zero. Under an OPMI Pico operating microscope (Carl Zeiss, Thornwood, NY) at 21.2× magnification, the apical 4 mm of the root was shaved along the long axis of the tooth in a plane that best demonstrated the minor diameter in relation to the file similar to previous studies (16, 17).

The roots were stained with methylene blue. Photographs of the specimen were taken at 15× and 30× magnifications. The images were projected at 360× and 720× on a screen. Two blinded investigators determined the location of the minor diameter. The distance of the

TABLE 1. Distance from the File Tip to the Minor Constriction (mm)

	Mean*	SD	Minimum	Maximum
Using rotary NiTi files				
Root ZX II (n = 28)	0.45	0.85	−0.96†	4.03
Apex NRG XFR (n = 28)	0.57	0.86	−0.65†	4.33
Mini Apex Locator (n = 28)	0.31	0.79	−3.07†	1.09
Using hand files (control)				
Root ZX II (n = 4)	0.16	0.11	0.00	0.24
Apex NRG XFR (n =4)	0.17	0.27	−0.14†	0.50
Mini Apex Locator (n = 4)	0.22	0.17	0.00	0.36

SD, standard deviation.

*Univariate analysis of variance: no statistically significant difference.

†Minus sign indicates file position coronal to apical constriction.

TABLE 2. File Tip Position Relative to the Minor Diameter

	Root ZX (n = 28)		NRG (n = 28)		Sybron Endo (n = 28)	
	n	%	n	%	n	%
Distance from minor diameter (mm)*						
<–1.0	0	0	0	0	1	4
−1.0 to −0.76	1	4	0	0	0	0
−0.75 to −0.51	1	4	1	4	2	7
−0.5 to −0.01	4	14	5	18	2	7
0.0 to 0.5	10	36	8	29	9	32
0.51 to 0.75	6	21	7	25	7	25
0.76 to 1.0	4	14	3	11	5	18
> 1.0	2	7	4	14	2	7
% Files past minor diameter		79		79		82

*Negative value indicates file position coronal to the minor diameter.

file tip to the minor diameter was then measured and recorded. The accuracy of each EAL in relation to the minor diameter was compared by using a one-way analysis of variance with repeated measures. The significance level was set at .05. Four teeth were lost during extraction or specimen preparation, leaving 32 teeth for analysis.

Results

All apex locators used with stainless steel hand files were able to locate the minor diameter of the control teeth within ±0.5 mm. The mean distance from the minor diameter to the file tip was 0.16 mm for the Root ZX II, 0.17 mm for the Apex NRG XFR, and 0.22 mm for the Mini Apex Locator past the apical constriction by using hand files.

The mean distances from the file tip to the minor diameter for the Root ZX II, Apex NRG XFR, and Mini Apex Locator by using rotary NiTi files were 0.45, 0.57, and 0.31 mm beyond the apical constriction, respectively. There was no statistically significant difference between the means, and the standard deviations were similar (Table 1), indicating similar accuracies among the 3 EALs. The accuracy of the Root ZX II, Apex NRG XFR, and Mini Apex Locator in locating the minor diameter within ±0.5 mm was 50%, 46.43%, and 39.29%, respectively, the accuracy within ±0.75 mm was 75%, 75%, and 71.43%, respectively, and the accuracy within ±1.0 mm was 92.86%, 85.71%, and 89.29%, respectively. The distance of the rotary NiTi file tip to the apical constriction for each file is illustrated in Table 2. The rotary file was past the minor diameter in 79% of the samples for the Root ZX II, 79% of the samples for the Apex NRG XFR, and 82% of the samples for the Mini Apex Locator. However, the file did not extend past the major diameter in most canals. The rotary file was past the major diameter 28.6% of the time for the Root ZX II, 28.6% of the time for the Apex NRG XFR, and 25% of the time for the Mini Apex Locator.

Discussion

Studies have shown that current EALs used with hand files are quite accurate in determining the location of the apical constriction. Welk et al (16) found that the Root ZX was 90.7% accurate in determining the apical constriction within ±0.5 mm. Tselnik et al (17) found that both the Root ZX and the Elements Diagnostic Unit and Apex Locator were accurate 75% of the time in locating the apical constriction within ±0.5 mm. Plotino et al (14) found similar high accuracies within ±0.5 mm of the apical constriction, ranging from 94%–100% accuracy for the Root ZX, Elements Diagnostic Unit and Apex Locator, and the ProPex.

In our control group, EALs with hand files did indeed have high accuracies in locating the apical constriction. All apex locators were able to locate the minor diameter of these teeth within ±0.5 mm. The mean distance from the minor diameter to file tip was 0.16 mm for the Root ZX II, 0.17 mm for the Apex NRG XFR, and 0.22 mm for the Mini Apex Locator.

EALs with rotary NiTi files were not as reliable as using hand files in locating the apical constriction within ±0.5 mm. The accuracy of the Root ZX II, Apex NRG XFR, and Mini Apex Locator in locating the minor diameter within ±0.5 mm was 50%, 46.43%, and 39.29%, respectively, with mean distances of 0.45, 0.57, and 0.31 mm past the minor diameter, respectively. It might be that EALs need time to process the position of the file within the canal. Rotary NiTi files are generally used with a continuous in and out motion, whereas the apical extent of hand files can be better controlled. This likely explains the higher accuracy obtained with hand files.

These results are in agreement with other studies. Jakobson et al (24) concluded that the auto-reverse function of the Root ZX II with the Low Speed Handpiece module was not able to control the apical extent of rotary instrumentation when the auto-reverse function was set to 1 or 2. Uzun et al (25) found that the Tri Auto ZX (J. Morita USA) and TCM Endo V (Tulsa Dental) with the auto-reverse function instrumented beyond the apical foramen in 60% and 95% of retreatment cases, respectively. They also found that these units were more accurate when used with files placed passively rather than when rotating.

Other studies have shown accurate results with the Tri Auto ZX (26–29). Grimberg et al (28) concluded that the Tri Auto ZX protected against overpreparation because it was able to automatically reverse within ±0.5 mm from the actual root canal length in all 25 teeth tested. Carneiro et al (29) concluded that the Tri Auto ZX with the auto-reverse function achieved clinically acceptable WLs.

In conclusion, the Root ZX II, Apex NRG XFR, and Mini Apex Locator used with rotary NiTi files were able to locate the apical constriction within ±0.5 mm only 50% or less of the time. Root ZX II with the auto-stop function had more accurate readings than the other EALs; however, the difference was not significant.

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