

Accuracy comparison of three different electronic apex locators in single-rooted teeth — an in vitro study

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Abstract

With many new inventions entering the dental field each day, endodontics has risen to a new level. Previously, root canal treatment was directed by “biomechanical preparation” and has shifted toward a “chemo-biomechanical preparation” methodology. Root canal treatment should be dependent on not only proper cleaning and shaping procedures but also access of the endodontic irrigants to the working length during treatment. The determination of correct working length is a very important factor leading to clinical success in root canal treatment. Numerous studies have demonstrated that when instrumentation and obturation reach the apical foramen, endodontic treatment provides predictable clinical results. Yet radiographic determination of working length with an endodontic file in the canal is an inaccurate method of deciding where the instrumentation and obturation needs to terminate. Therefore, accurate determination of the location of the working length is a very important factor in successful root canal treatment.

Introduction

Electrical resistance between the mucous membrane and periodontium can be considered to have a constant relationship, so a method for measurement can be developed. Therefore, measuring the length of the canal

by electrical resistance would be possible.¹ Working length (WL) determination is a very important factor in the success of root canal treatment. Failures in determination of WL such as measuring short or beyond the apex may cause failure of the root canal treatment due to placement of obturation material beyond the confines of the anatomic root. Therefore, clinicians need to obtain accurate measurements during WL determination to yield predictable clinical results.²

Numerous studies have demonstrated different histological results after root canal treatment and have shown superior results when instrumentation is performed as well as obturation to the apical constriction (apical foramen). Thus, determination of the accurate WL by locating the minor apical diameter is very important for successful root canal treatment.² Yet radiographic determination of working length with an endodontic file in the canal is an inaccurate method of determining where the instrumentation and obturation needs to terminate. The aim of this study is to evaluate the accuracy of three different electronic apex locators in single-rooted teeth.

Materials and methods

Sixty extracted human single-rooted permanent teeth with completely formed apices were used as study samples. The teeth were extracted for periodontal, prosthetic, or orthodontic reasons. After extraction, the teeth were placed in 5% sodium hypochlorite to remove the periodontal ligament. Stains and calculus were removed with the help of hand scalers and curettes. Selected teeth were stored in a container containing 2% thymol crystals in distilled water until needed for the study. Endodontic access was prepared with burs using a high-speed handpiece. The study samples were analyzed for actual working length with the aid of a stereo microscope under 40x magnification by multiple observers, with a mean value of three observers set as the actual working length. A size 15 K-file was inserted into each study sample to access the root canal working length. Care was taken that each sample

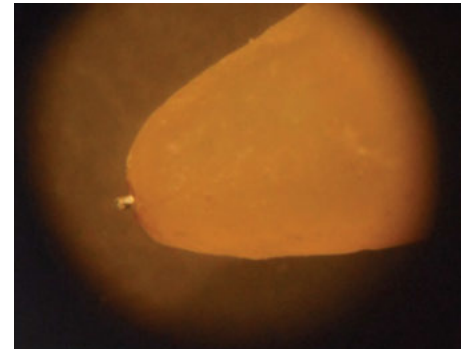


Figure 1: Microscopic working length reading with file at the apex

was placed properly on the tray of the stereo microscope so that complete working length was analyzed. The apical exit of the inserted endodontic file was noticed (Figure 1), and the file was removed from the canal without changing the placement of the rubber stopper. The working length was measured with an endo gauge; the procedure was repeated for each study sample 3 times by each observer, and the mean value as actual working length was set. The 60 extracted teeth were then divided into three groups.

Each tooth was placed in a container poured with alginate that was mixed with a saline liquid to replicate the conduction of electricity to simulate an oral environment. The lip clip was placed into the alginate, and the wire from the apex locator was connected to the file.

Group 1 Containing 20 extracted human anterior single-rooted teeth whose working length was taken by using RAYPEX® 6 electronic apex locator (VDW®, Munich, Germany) (Figure 2, left).

Group 2 Containing 20 extracted human anterior single-rooted teeth whose working length was taken by using ROOT ZX II electronic apex locator (J. Morita Corp., Osaka and Tokyo, Japan; J. Morita USA, Inc., Irvine, California). (Figure 2, center).

Group 3 Containing 20 extracted human single-rooted teeth whose working length was taken by using Propex II™ electronic apex locator (Dentsply Sirona, York, Pennsylvania) (Figure 2, right).

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The observers then recorded three readings for each sample by reinserting the No. 15 K-file, and measurements were obtained with the three Electronic Apex Locators: Root-ZX II (J. Morita), Propex II (Dentsply Sirona) and Raypex 6 (VDW). (Figure 3) These values were then compared with the actual working lengths previously obtained.

Statistical analysis

All the statistical analysis was performed using SPSS version 18 and MedCalc® Version 14. A p-value of < 0.05 was considered statistically significant.

Statistical analysis was performed using paired t-test and Kruskal Wallis ANOVA with post-hoc Conover test. Statistical readings were considered significant when $p < 0.001$.

Results

The mean value of working length for group 1 was 23.11 mm, and the standard deviation was 1.86 as measured with the microscope. The mean value of this group's working length with the apex locator was 22.7 mm, and the standard deviation was 1.8.

The mean value of working length of group 2 was 20.98 mm, and the standard deviation was 1.76 as measured with the microscope. The mean value of working length for group 2 was 20.19 mm, and the standard deviation was 1.47 with the apex locator reading.

The mean value of working length of group 3 was 21.33 mm, and the standard deviation was 2.45 as measured with the microscope. The mean value of working length of group 3 was 20.52 mm, and the standard deviation was 2.22 in apex locator reading.

The absolute agreement among the readings of the three apex locators was checked by intra-class correlation coefficient (0.93).

The absolute agreement among the three microscope readings was checked by intra-class correlation coefficient (0.92).

Discussion

Correct working length determination is the main factor leading to success in endodontic treatment. Studies have shown the histological results after endodontic treatment to be superior when instrumentation and obturation are limited to the apical foramen and not beyond this anatomical landmark. Therefore, accurate determination of the location of the apical constriction is a key factor in successful endodontic therapy.³

In 1918, Custer was the first to report the use of an electric current to determine working length. In 1962, Sunada reported that there is a constant value (6.5k ohms) of electrical resistance between the mucous



Figure 2: Electronic Apex Locators (EAL) used in the study



Figure 3: Apex locators recording working length on specimen samples

	Apex Locator		Disinfection Protocol		p-value
	Mean	SD	Mean	SD	
Group 1	22.73	1.88	23.11	1.86	< 0.001; Sig
Group 2	20.19	1.47	20.98	1.76	< 0.001; Sig
Group 3	20.52	2.22	21.33	2.45	< 0.001; Sig

	Difference of microscope — apex locator working length		p-value	Post hoc test
	Mean	SD		
Group 1	0.37	0.22	0.015	Group 2, 3 > 1
Group 2	0.78	0.51		
Group 3	0.82	0.77		

membrane and the periodontium and stated that it is possible to use this value of resistance in the estimation of root length. Additionally, he demonstrated that if an endodontic instrument is connected to an ohm meter — introduced into the canal and advanced until the ohm meter shows the value of 40 ohms — the tip of the instrument has reached the periodontal ligament at the apical foramen. The device utilized by Sunada in his research became the basis for electronic apex locators.³

In the study presented here, three different electronic apex locators were utilized (Root ZX II, Propex II, and Raypex 6) whose electronic working length was compared to the actual root length using a stereo microscope to determine the actual working length. The results demonstrated that the accuracy of the Raypex 6 EAL was more accurate than the Root ZX II EAL, which is similar to a study conducted by Samadi, et al.⁴ Additionally, the Propex II was not as accurate as the Raypex II as reported by Demiriz, et

al.⁵The data collected in the study presented here found a statistically significant difference between the Raypex 6 EAL and the other two units evaluated by up to 1 mm between the samples studied. Comparison of accuracy between the RootZX II and Propex II demonstrated near equal accuracy between these two EALs.

Lucena-Martin, et al., conducted a study to evaluate several apex locators and found that the Root ZX II was more reliable among the apex locators he evaluated.⁶ Haffner, et al., also conducted a study comparing apex locators with a microscope and confirmed that apex locators are very reliable in determining working length.⁷ D'Assunção, et al., evaluated two apex locators and found that apex locators are reliable in locating the apical foramen, thus confirming prior reported studies.⁸ Sadeghi and Abolghasemi compared apex locators with the conventional radiographic method in straight and curved root canals and found apex locators are reliable in determining working length, regardless of the curvature or lack of curvature of the root.⁹

Studies also have stated that the use of an electronic apex locator for working length determination is a much easier procedure and more accurate than taking the working length measurements with a radiograph and a file within the canal. An added benefit is minimization of radiation exposure to the patient. Thus, we can conclude that electronic apex locators are more accurate than alternative methods to clinically determine working length, saving chair time, and decreasing patient radiation exposure.

Conclusions

The study was performed to compare the accuracy of three different electronic apex locators in single-rooted teeth in vitro, in which the following key points were concluded:

1. The use of an electronic apex locator is a reliable and accurate method in determining working length.
2. There is a minor difference between actual working length taken by a stereo microscope and working length taken by electronic apex locator.¹²
3. The Raypex 6 electronic apex locator is most reliable in the determination of working length, followed by the Propex II electronic apex locator and the Root ZX II electronic apex locator.

The use of an electronic apex locator is an excellent adjunct to the practice of endodontics, provided accurate working length and clinical results can be obtained consistently with time savings during treatment. A

perceived disadvantage of electronic apex locators has been the concern in use with patients who have implanted pacemakers or defibrillators. Yet multiple published studies have found the EAL has no negative effect on these implanted devices, and they are safe to use in these patients.¹⁵⁻¹⁷ **EP**

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