Estimation of Root Canal Working Length Using Three Different Apex Locators, An In-Vitro Study

Ammar Azeaz Lateef [1], Samer Aun Thyab[2] , Noor Salman Nadhum[3]

[1]M.Sc. Lecturer, [2]Lecturer, [3]Assistant Lecturer, Department of Restorative and Aesthetic Dentistry, College of Dentistry, University of Baghdad, Iraq

Abstract

Introduction: The purpose of this study was to compare the accuracy of different generations of electrical apex locators (EALs) using different measuring protocols. The accuracy of E-PEX PRO (Eighteeth, Changzhou, China) as newly introduced device, Root ZX (J Morita Corp, Tokyo, Japan), and iPex (NSK, Tochigi, Japan) EALs were evaluated.

Methods: In this study thirty extracted human permanent single rooted premolar were used. The working length was determined with #15 K-file, then by one of the three EALs, first by introducing the file into the canal until the EAL reads 0.0 then retracting the file until it reads +1.0, second by proceeding the file until the EAL reads +1.0. The data were analyzed using One-way repeated measure ANOVA test at P value of (0.05).

Results: No statistically significant differences were found between the three EALs at either measuring protocol

Conclusions: Under the in-vitro conditions of the current study, all tested EALs were accurate in estimating working length.

Key Words: *IN-VITRO, Apex locator, Working length, ROOT CANAL,*

Introduction

Endodontic treatment accuracy depends on the actual debridement, cleaning, and obturation of the root canal to the full working length at the cementodentinal junction (CDJ), especially in infected canals.[1] Several studies have been conducted to determine the apical constriction position and concluded that the CDJ is about 0.5-0.6mm to the apical foramen. The apical foramen position is about 0.3-3.8mm distal to the anatomical apex of the root. [2-4] WL determination is pivotal for successful endodontic treatment. X-ray radiographs give information about the root's shape, number of canals, and adjacent anatomical structures. However, the radiographs alone cannot be reliable to determine WL accurately because of anatomical variations, superimposition of tissues, distortion of the image, elongation and shortening of the roots, and the lack of three-dimensional interpretation. [5,6] Alternatively, the successive electronic apex locator's (EALs) generations has shown a promising results to achieve accurate WL[7], some of these devices use two different frequencies at the same time in order to measure the difference or ratio between two currents, and others use two or more non-simultaneous continuous frequencies in order to measure the difference or ratio between two currencies.[8,9] This study aims to compare the accuracy of WL determination among three types of EALs from two different generations; Root ZX (J Morita Corp, Tokyo, Japan), iPex (NSK, Tochigi, Japan), and E-PEX PRO (Eighteeth, Changzhou, China) following two measuring protocols.[Table1]

Corresponding Author:
Samer A Thyab
Department of Restorative and Aesthetic Dentistry, College of Dentistry, University of Baghdad, Iraq.
Phone numbers: 009647904897764.
E-mail address samer13thyab@gmail.com

Materials and Method

Thirty single rooted teeth with a complete apex formation were used in this study, those teeth were extracted either for orthodontic or periodontic reasons, immersed in 2.5% sodium hypochlorite solution for 4 hrs to remove any soft tissue remenants on root surface , if any calculus present it was removed by ultrasonic tip and then stored in a 2% thymol solution , teeth were numbered and an endodontic access cavity was made by diamond bur using high speed handpiece with copious cooling , the cusp tips were cut flat for a proper positioning of the rubber stopper of the file.[10]

The cervical and middle third were prepared using SX protaper (Dentsply Maillefer) [11,12], the canals were irrigated with 2.5% sodium hypochlorite solution then dried, #10 k file used to negotiate into the apical third of each canal till the tip was seen through the main foramina using stereomicroscope 40x, then #15 k file inserted into the canal till it appears nearly through the main apical exit (Figure 1). the stopper was adapted at the reference point and the measurement were taken with an endo gauge then 1mm was subtracted to determine the WL. This procedure was repeated for each sample by three observers and the mean value was set as the actual WL.[13]

After completing the actual measurement, each sample was fixed in a container poured with alginate mixed with saline solution to simulate the electricity of the oral tissue[12-17] the lip clip of EAL was dipped into the alginate and the wire hook attached to #15 k file then inserted into the canal till the EAL reads 00 (Figure 2), after that the file was pulled up slightly till it reads -1, the rubber stopper was adapted to the reference point and the endo gauge used to read the measurement as the WL value, in the second measuring protocol the #15 k file introduced into the canal till the EALs reads -1 mm which considered as the WL value, this procedure repeated by three observers for each sample and the mean value set as the final WL, the data were collected using the three EALs.[18]

The data were allocated into two major groups of measuring protocols. Each group is subdivided into four subgroups, either manual (control) or one of the three EALs types.(Table 2)

Statistical Analysis

To test the normality of measurements, Shapiro-Wilk test was performed between the four groups of each WL measurement protocol. One-way repeated measure ANOVA test at P value of (0.05) was calculated to find any significant difference between the three EALs readings compared to the manual method. A manual method of WL measurement was considered as the golden standard method to which each one of the other EAL readings were compared to in pairs using intraclass correlation coefficient (ICC) analysis. Agreement between examiners was calculated for each method, using the manual (control) values of the devices, by intraclass correlation coefficient (ICC) analysis. Statistically the data were analyzed with SPSS software version 23.00 (IBM Corp, Armonk, NY, USA).

Results

Table 1: Different generations of electrical apex locator devices and their operation base

Device	Operation base	Generation
Root ZX (J Morita Corp, Tokyo, Japan)	Using two different frequencies at the same time in order to measure the difference or ratio between two currents	Third
iPex (NSK, Tochigi, Japan)	Using two or more non-simultaneous continuous frequencies in order to measure the difference or ratio between two currents	Fourth
E-PEX PRO (Eighteeth, Changzhou, China)		

The descriptive data are presented in table 2.

Table 2: The descriptive data

	GROUPS	NUMBER	Min	Max	Mean	Std. Devi.
First protocol	I PexII	30	17.50	27.00	20.8	2.74
	ZX Mini	30	18.00	26.50	20.95	2.45
	Eighteeth	30	17.50	27.00	20.93	2.68
	Manual WL	30	18.00	27.00	21.03	2.63
second protocol	I PexII	30	17.00	26.00	20.13	2.58
	ZX Mini 1	30	17.00	25.50	19.95	2.45
	E PEX PRO	30	17.00	26.00	20.14	2.6
	Manual WL	30	17.00	26.00	20.03	2.63

The intraclass correlation coefficient (ICC) analysis showed acceptable level of agreement between examiners for all methods (0.704), ranging from 0.561 to 0.925. According to Shapiro-Wilk test, readings of all groups were normally distributed around means. One-way repeated measure ANOVA test at P value of (0.05) showed no significant difference between the groups of each tested protocol. The results of comparing between manual method of canal length measurement with each one of the other EAL readings were compared in pairs as illustrated in table 3.

Whatever the protocol for canal length measuring, all the tested EALs gave readings of close proximity to that of the golden standard method with no statistically significant differences.

Table 3. The results of comparing between manual method of canal length measurement with each one of the other EAL readings were compared in pairs

Intraclass Correlation Coefficient	First protocol			Second protocol		
Device	I PexII	Root ZX Mini	E-PEX PRO	I PexII	Root ZX Mini	E-PEX PRO
Average Measures	0.998	0.997	0.995	0.998	0.997	0.995

Discussion

Different generations of EALs have entered the practice over these past few decades with improved functions and more significant clinical applications. The third generation apex locator is described as a frequency-dependent apex locator supplied by two frequencies to measure the impedance in the canal. The sensitivity to canal fluid and the device needs for a fully charged battery is reported as the disadvantages of this generation.[19] On the other hand, The fourth generation apex locator measures the impedance characteristics using more than two frequencies.[20] This generation device's disadvantage is the demand to perform in relatively dry or in partially dried canals.[21] By comparing these two generations, our study's results indicated that there were no significant differences between different EALs of the third and fourth generations.

By comparing the ability of various generations of EALs to determine root canal length, many studies showed that EALs were accurate for WL measurement within a clinically acceptable range of ± 0.5, which comes in agreement with previous investigations.[22-24] On the contrary, other studies mentioned that some third generation EALs were more accurate than those of the fourth generation.[25-27]

Concerning the measuring protocols, despite the non significant difference between the two measuring methods, the clinical impact of investigating different protocols on WL accuracy using EAL might potentially affect the device ease of use and patient acceptance, which up to the author's knowledge, was first tested in this study.

Conclusion

Within this study's limitation, the proximate accuracy in WL measurements between the three types of EAL from two different generations following alternative measurement methods gives the clinician the freedom to choose the most cost-effective EAL and user-friendly protocol without the burden of measurement errors.

Financial Disclosure: There is no financial disclosure.

Conflict of Interest: None to declare.

Ethical Clearance: All experimental protocols were approved under the Department of Restorative and Aesthetic Dentistry and all experiments were carried out in accordance with approved guidelines.

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