Original Article

Accuracy Of Electronic Method In Working Length Determination In Different Modes -An In Vitro Study

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Abstract:

Background:

Determining the root canal length accurately has been a challenge in endodontics. The accurate determination and even estimation of apical constriction is not possible with radiographic method. Electronic methods are now widely used during endodontic treatment for the assessment of root canal length.

Aims and objectives:

The aim of this study is to evaluate the influence of different irrigants in the accuracy of electronic apex locator in determination of the tooth length.

Materials and Methods:

This, in vitro study compares the effectiveness of dual frequency dependent Electronic apex locator under dry mode and in the presence of various irrigants as for Normal saline (NaCl), 3% Hydrogen peroxide (H_2O_2) and 5.2% Sodium hypochlorite (NaOCl).

Sixty extracted, single rooted & single canal human anterior teeth were used. Actual length was confirmed by the file tip viewing at the level of the apical foramen under stereomicroscope. The teeth were then mounted in alginate mould. The measurements were obtained by Electronic Apex locator were compared with actual length and subjected to statical analysis by one way ANOVA and Post Hoc Games Hawell test at the 5% significant level.

Results:

No significant statistical difference was found between actual length of the canal & Electronic apex locator measurements under dry mode and in presence of saline where as statistical significant difference was found in presence of H_20_2 & NaOCl.

Conclusion:

The result of this study indicate that the frequency based Electronic Apex Locator (EAL) can accurately determine the tooth length even in presence of intracanal irrigating solution.

Key words:

Electronic apex locator, working length, irrigants, NaCl, H_2O_2, NaOcl

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Introduction

The endodontic success depends on the complete removal of all pulp tissue, necrotic material and microorganisms from the root canal. This can only be achieved if the length of the root canal is determined with accuracy.

It is generally accepted that root canal treatment procedures should be limited within the root canal system. Therefore, one of the main concerns in root canal treatment is to determine how far the instruments should be advanced within the root canal and at what point the preparation and filling should terminate [1]. Thus, the procedure for calculation of working length should be performed with skill, using techniques that have been proven to give valuable and accurate results and by methods that are practical and efficacious and is perhaps the most important decision made during endodontic treatment.

The common methods of working length determination are radiographic methods, digital tactile sense, and electronic method. Traditional methods for establishing working length such as the use of anatomical averages and knowledge of anatomy, tactile sensation, and moisture on a paper point and radiography may lead to incorrect conclusions [2].

The manual technique obviously depends on the sensitivity and experience of the operator, whereas in the radiologic approach, the calculation of the working length was made with respect to the position of the radiographic apex.

It is impossible on the radiographic film to consistently detect the major and minor foramina, or cement-dentinal junction. Thus, they are open to misinterpretation in a number of cases [3]. This may result in a possible clinical error in length determination.

One of the innovations in root canal treatment has been the development of electronic devices for detecting the canal terminus. It eliminates many of the problems associated with radiographic methods and it attempts to measure the length of the root canal either to the end of apical constriction or at apical foramen. It is more accurate, easy and fast, with no requirements of X-ray exposures [4].

Human tissues have certain characteristics that can be modeled by means of a combination of electrical components. Oral soft tissue conducts electricity relatively easily. Hard tissue, on the other hand, acted as an insulator thus all electronic apex locators flowed the current from the device and establish a circuit through the two electrodes in the mouth, one electrode attached to the file and another electrode ground in the lip of the patient, the current flow back from the circuit to the device that would indicate or display in the monitor where the file was in the canal or it reached to the apex [5].

But, many of the acquisition, being made to EALs in its accuracy due to shortcomings like biological phenomena such as inflammation [6], vital tissue, exudates, blood [7], and strong electrolytic irrigants like sodium hypochlorite [8] that create the probability of early electric circuit formation before reaching the apex.

To overcome the problems, various electronic methods therefore, had been developed that use a variety of other principles like high frequency, dual or multiple frequency, low frequency oscillation current to detect the canal terminus [5].

Irrigation is presently the best method for the removal of tissue remnants and dentine debris during instrumentation. It also provides gross debridement, lubrication, destruction of microbes and dissolution of tissues[9]. But, the influence of these electroconductive irrigants on the efficiency and accuracy of EAL leads to further questions.

The manufacturers of modern apex locators (frequency dependents) claim to be effective and accurate in presence of any electro-conductive irrigants in the canal such as NaOCl, NaCl, and EDTA (ethelene diamine tetra acetic acid) solution. The effect of irrigating solutions on Foramatron D[10] which is frequency based EAL has not been reported yet. Therefore, the main objective of this study is to evaluate the accuracy of EAL in tooth length determination in presence of different irrigants.

Materials and Methods:

Sixty human maxillary and mandibular anterior teeth were selected for the study after clinical and radiographical evaluation. All the selected teeth were immersed in 1% sodium hypochlorite solution in a screw capped glass vial for 24 hours to remove any organic debris from the surface followed by cleaning with hand and ultra-sonic Scalar. Then, all the teeth were again immersed in distilled water for 24 hours prior to tooth preparation.

Specimen Preparation:

The pulp chambers were accessed with a 701 or 702 tapered fissure bur or (straight fissure bur) in an High speed contra angle handpiece with proper cooling arrangement. The roofs of the pulp chambers were removed with no. 2 or 4 round burs at slow speed in contra angle micro-motor handpiece. The canal orifices were located by an endodontic explorer. Any residual pulp tissue was removed from the root canals with a barbed broach or H-File (Mani Inc, Tokyo Japan).

Canal orifices were enlarged with # 2 and # 3 Gates-Glidden (Premier Dental Co. Norristown, PA) in a contra angle micromotor handpiece. Any irregularities, if present on incisal edges of the teeth were then, trimmed by straight fissure bur to have the univocal reference point.

The final procedures were held in four phase:-

Phase One

All Sixty teeth were measured using a no.10 or no. 15 K-file (Mani Inc, Tokyo Japan) until it was just visible through apical foramen that was confirmed by viewing them in Stereomicroscope (Meiji Techno. Co. Ltd. Tokyo, Japan) at x14 magnification (Figure 1) and photographed for recording (Figure 2and 3). Each specimen was investigated by a neutral examiner experienced in reading them. The rubber stopper was adjusted to the level chosen as reference point for root canal measurement. An Endodontic Gauge (GC Corporation Tokyo, Japan) which was 0.5mm accuracy measurement and was used to measure the distance from the stopper to the file tip. Measurement of each tooth was repeated for three times and the mean value computed. The measurements obtained by the Stereomicroscope of all teeth were consider as the 'Gold standard' and was also consider as the actual length of those teeth to which all other measurements were compared.

Phase Two

A plastic box of 7x2cm was selected so that the prepared teeth can be fitted into them in standing position. Alginate (Lygin, Dentamerica) was mixed with 1% Sodium Chloride which acts as a conducting gel simulating the periodontium. The teeth were inserted in plastic box one by one and waited until set. The alginate base were then removed from plastic box and cut into suitable cubical shapes as convenient (Figure 4). In the same manner, all the teeth were mounted in the alginate bases separately. When not in use the models were wrapped with the damped cotton and refrigerated (Figure 5and 6). The teeth with alginate bases were kept in a moist environment throughout the study period (5 days).

Phase Three

During electronic measurement by Electronic apex locator (Foramatron D10, Parkell Electronic Division, Farmingdale, New York, USA), the cord with labial clip of the corresponding apex locator was inserted into the alginate which was cut in the middle (Figure 7). The remaining cord of electronic apex locator with a hook was latched into the ISO 15 no. K-file (Mani Inc, Tokyo Japan). It was ensured that the hook of the EAL was in proper contact with the file.

All the 60 no. of teeth were measured in dry mode (as being not used any irrigant solution) with electronic apex locator according to the manufacturer's instruction (Figure 8). When the tip of the file approaches the foramen, the graphical display illuminated. All the measurement of sixty teeth in dry mode of the canal was taken and noted down in data sheets, then each measurement was repeated three times and the mean value computed.

Phase Four

Various types of irrigants were used in the canal and measurements were taken by EAL. The irrigants used were

A) 1% of NaCl

B) 3% of H_2O_2

C) 5.2% of NaOCl

All three irrigating solutions were injected by 3ml disposable syringe in the entire sixty teeth one after another consecutively (Figure 9, 10 and 11). The irrigant solution overflowed to the pulp chambers was soaked with small cotton ball. After the completion of measurements in all sixty teeth, it thoroughly flushed out with distilled water two three times and dried with 15 no. and 20 no. paper points (Meta Dental Corp. Korea). It was refrigerated until next irrigants used. During the procedure of measurement, few of the alginate bases were distorted while handling so they were discarded and new cubical bases were prepared again.

Result

The present study was undertaken on 60 teeth to evaluate the influence of different irrigants on the accuracy of electronic apex locator in estimating length of root canal. Stereomicroscopic measurements were considered as the actual length of the teeth with which all other measurements were compared. Measurements of EAL were taken in dry mode and in presence of irrigants as for NaCl, H_2O_2 and NaOCl.

Table I. Range of deviation with actual value for tooth length measurement in different in mode (Tooth Length Measurement in mm)

No of teeth	Measurement	Mean	SD	Mode	Maximum	Minimum
60	Stereo Microscope	20.09	±1.627	18.3	23.3	17.3
	Dry Mode	20.07	±1.61	20.3	23.5	17.3
	NaCl	20.06	±1.63	19.0	23.6	17.3
	H_2O_2	19.95	±1.63	18.5	23.5	17.1
	NaOCl	19.96	±1.68	19.9	23.8	17.1

Table II. Approximation of tooth length measurement accuracy in different modes:

Approximation of tooth length measurement accuracy (mm)# (Range)	Measurement mode				p-value
	Dry mode	Sodium chloride	Hydrogen peroxide	Sodium hypochlorite	
-0.5 - 0.0	43(71.0)	22(36.7)	11(18.3)	17(28.3)	
0.01 – 0.5	15(25.0)	38(63.3)	41(68.3)	32(53.3)	<0.001
0.51 – 1.0	2(3.3)	0(0.0)	7(11.7)	8(13.3)	
> 1	0(0.0)	0(0.0)	1 (1.7)	3(5.0)	

Figures in the parentheses denote corresponding % and Figures outside the parentheses denote the no. of teeth.

Data were analysed using Chi-square ((2) and level of significance was 0.05.

In terms of approximation of accuracy dry mode was the best as 71.7% of it gave an accuracy within - 0.5 – 0.0 mm of stereomicroscopic measurement, NaCl had the second highest accuracy as 36.7% of it was found to lie within an accuracy of - 0.5 – 0.0 mm. Likewise the NaOCl and H_2O_2 had the third and the least accuracy (28.3% and 18.3% respectively), when error was considered with - 0.5 – 0.0 mm) (Table II). All the four groups were significantly heterogeneous in terms of approximation of measurement accuracy ($p < 0.001$).

Fig. 1: Comparison of percentage of error among the working modes

Stereomicroscope

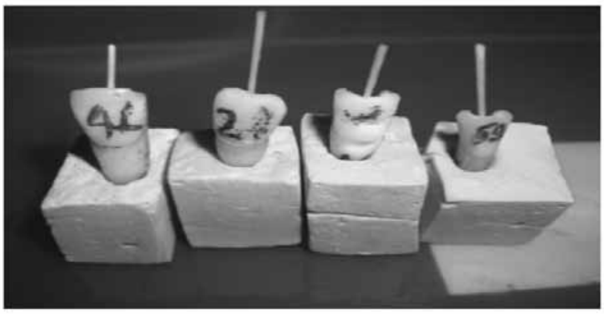
Figure 1

Digital Monitor

Figure 2

Some pictures taken by digital monitor of apical foramen

Figure 3



Preparation of alginate blocks with teeth Mounting

Use of damped cotton to moisten the alginate

Figure 5

Stored in refrigerator

Figure 6

Alginate cube cut in middle

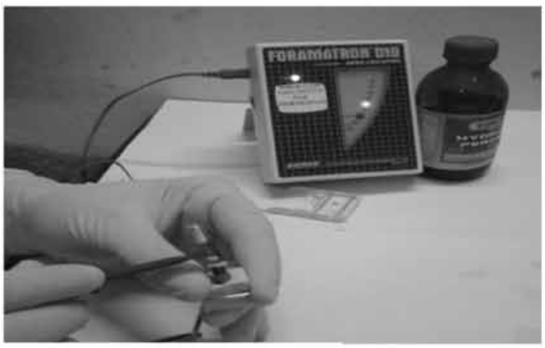
Figure 7

Measurement taken in dry mode of the teeth

Figure 8

Measurement taken in presence of NaCl

Figure 9



Measurement taken in presence of H_2O_2

Figure 10

Measurement taken in presence of NaOCl

Figure 11

Discussion

Clinically, determination of working length for preparation and obturation play a vital role in the success of endodontics which should be at or short of apical constriction [10] and it usually lie 0.5 to 0.8 mm from the major diameter [11] or apical foramen. Most manufactures of modern EALs in their reports suggested to subtract 0.5 mm from the length of the file at the point when the device suggest the 0.0 reading or display apex to obtain the apical constriction or the most suitable working length of the root canal [5].

Since the introduction of the frequency dependent EAL, much popularity in its use had been gained. It had shown accuracy even in the presence of electroconductive irrigation solutions. Data of the study showed the mean absolute error was the lowest in dry mode and out of 60 teeth, 43 teeth coincide with the actual length measured by stereomicroscope. Here the maximum error difference was 1mm and minimum difference in error is -0.1mm.

The moisture content of the root canal was one of the essential factors influencing the accuracy of electronic root canal measuring device. Many of the studies used an error range of ±0.5 mm to assess the accuracy of the EALs [12].

Measurements attained within this tolerance were considered highly accurate. In comparison to these standards the measurements of the EAL if taken within ± 0.5mm to the foramen as clinically acceptable tolerance range, the accuracy of the present study was 100% in NaCl and 96.5% dry mode where as H2O2 and sodium hypochlorite with similar accuracy of 86.6 % and with 81.7

% respectively under clinically acceptable range of error tolerance in comparison with to measurement taken by Stereomicroscope.

Many of the root canals do not always end with an apical constriction, a well-delineated minor or major apical diameter, or an apical foramen within the base of the cemental cone. With a lack of such demarcations, an error tolerance upto ±1.0 mm to the foramen is deemed to the clinically acceptable range of tolerance [13].

Although sodium hypochlorite gave the highest percentage of error, the wide use of this irrigant solution cannot be avoided in endodontic therapy and has superiority action and acceptance [14].

Manufacturers EALs although claimed that their apex locators were accurate in a wet canal, they were more accurate in a dry canal. It is especially important to have a dry chamber floor in teeth with multiple canals because the electrical current will bridge across the fluid on the chamber floor and travel down multiple canals [15].

Root ZX and dual frequency Foramatron D10 showed significantly similar and better scores. Foramatron D 10 not only it lived up to what manufacturer claimed of accuracy. Many recent developments have been found in EAL as with the introduction of EAL in combination with electric handpieces for as SOFY ZX (J. Morita), Dentaport ZX (J. Morita), Endy 7000 (Ionyx SA, Blanquefort, France), Tri Auto ZX (J. Morita Corp.) and should be able to achieve excellent results with the same accuracy as the stand-alone units [16].

Conclusion

According to the vitro study finding, over all absolute error obtained by EAL in dry mode were lowest to the actual length measured by stereomicroscope.

The use of NaCl is equally preferable as it gave 100% accuracy within ± 0.5mm clinically acceptable range of error. All the measurements taken by EAL in presence of irrigating solutions by H2O2 and NaOCl are satisfactory as both gave the accuracy 86.6% and 81.7% in a clinically acceptable range of tolerance ± 0.5mm whereas 98.3% and 94.9% in clinically acceptable range of tolerance ± 1mm.

Even if clinician preferred to use NaOCl and H2O2 before working length determination or during instrumentation like in EALs incorporated with engine driven handpieces, one may safely use electroconductive irrigants.

However, further investigation using greater sample size and most recent EAL in different canal condition and other irrigating solution as well as clinical evaluation is required.

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