doi:10.5368/aedj.2011.3.1.1.6

EVALUATION OF THE ACCURACY OF TWO APEX LOCATORS AND RADIOVISIOGRAPHY-AN IN VITRO STUDY

[1]Ramesh T — [1]Assistant Professor, Department of Conservative Dentistry
[2]Jaya prakash D patil — [2]Professor and Head, Department of Conservative Dentistry
[3]Chandrasekhar M — [3]Director, Professor and Head, Department of Conservative Dentistry

[1,3] Government Dental College and Hospital, Rajiv Gandhi Institute of Medical Sciences, Kadapa, Andhra Pradesh.
[2] Sri Sai College of Dental Sciences , Vikarabad, Andhra Pradesh.

ABSTRACT

Determination of an accurate working length is one of the most critical steps of Endodontic therapy. The cleaning, shaping and obturation of root canal system cannot be accomplished accurately unless working length is determined precisely. Locating the appropriate apical position always has been a challenge in clinical Endodontics. The cementodentinal junction (CDJ), where the pulp tissue changes into the apical tissue, is the most ideal physiologic apical limit of the working length. However, the CDJ and apical constricture do not always coincide, particularly in senile teeth as a result of cementum deposition, which alters the position of the minor diameter. In an attempt to measure the working length to a value that almost coincides with the actual length or anatomic length and to overcome all the errors that could occur due to the limitation of the present techniques used, electronic apex locators with their inherent capacity to minimize the errors and the simplicity of the technique involved in the calibration of working length seems to be an important break through in the field of Endodontics. Modern electronic apex locators can determine this position with accuracies of greater than 90% but still have some limitations. Knowledge of apical anatomy, prudent use of radiographs and the correct use of an electronic apex locator will assist practitioners to achieve predictable results.

KEY WORDS: Working Length, Apex Locator, Radiovisiography, Operating Microscope

INTRODUCTION

Determination of an accurate working length is one of the most critical steps of Endodontic therapy. Locating the appropriate apical position always has been a challenge in clinical Endodontics. The cementodentinal junction (CDJ) is a practical and anatomic termination point for the preparation and obturation of root canal and this cannot be determined radiographically. The cementodentinal junction (CDJ), where the pulp tissue changes into the apical tissue, is the most ideal physiologic apical limit of the working length[1]. However, the CDJ and apical constricture do not always coincide, particularly in senile teeth as a result of cementum deposition, which alters the position of the minor diameter[2]. Suzuki (1942)[3] indicated that the electrical resistance between a root canal instrument inserted into a canal and an electrode applied to the oral mucous membrane registered constant value (6.5 Kilo Ohms). Second generation Electronic apex loacaters (EAL) measure impedance, which is a complex function of inductance and capacitance found in any alternating current, and is considered generalized resistance[4,5]. Electronic apex locators help to reduce the treatment time and eliminate the radiation dose, which may be higher with conventional radiographic measurements[2].

Aims and objectives

The aim of the present study is to evaluate the ability of Root ZX, Foramatron D10 and Radiovisiography in determining the working length and comparing with actual working length determined by using operative microscope.

Objectives

1. To evaluate the accuracy of Root ZX for working length determination.
2. To evaluate the accuracy of Foramatron D10 for working length determination.

3. To evaluate the accuracy of Radiovisiography for working length determination.

4. To compare working lengths (Root ZX, Foramatron D10, and Radiovisiography) with the actual lengths.

Materials and methods

Materials

1. Sixty extracted, single rooted, human permanent teeth,
2. 3% sodium hypochlorite (Vishal Dentocare PVT LTD),
3. 0.9% saline (CLARIS Life Sciences),
4. Disposable Syringe (Dispo Van, HMD LTD),
5. Dappendish,
6. Diamond disc (Horico),
7. Airotor handpeice (NSK, Pana Air, Japan),
8. Micromotor contrangle handpiece (NSK, Japan),
9. Micromotor straight handpiece (Marathon-4, Saeyang Microtech),
10. Gates Glidden drills – 3, 4, 5 and 6 (MANI CE 0197 Prime Dental Products PVP LTD),
11. Diamond bur (MANI CE 0197 Prime Dental Products PVP LTD, DIA-BURS),
12. Flexofiles - no: 15, 20, 25 sizes (Dentsply Maillefer),
13. Alginate (Zelgan),
14. Small plastic containers,
15. Putty impression material (Exaflex),
16. Modeling wax (Ashoo Sons, Rolex),
17. Digital Calipers (Aerospace, China)
18. Operative Microscope (Seiler Instrument and Manufacturing Co., Inc., St. Louis, MO)
19. Root ZX (J. Morita, Tokyo, Japan),
20. Foramatron D10 (Parkell Dental, Farmingdale NY, USA),
21. Radiovisiography (Eva).

Methodology

This study involved sixty single rooted, human permanent (incisor and canine) teeth with mature apices which were extracted due to periodontal reasons. The teeth were soaked in 3% sodium hypochlorite for 6 hours. After 6 hours the teeth were cleaned off soft tissue, calculus and stains with the help of sharp sickle hand scaler, later they were thoroughly washed under running tap water to remove any remaining tissue remnants sticking to the tooth surface and were stored in 0.9% saline till further usage.

The crowns were sectioned with diamond disc in the cervical region perpendicular to the long axis using a straight hand piece to allow access to the root canal. The sectioned surfaces were marked with long tapered diamond for the stable reference point. Gates Glidden drills #3, 4, 5 and 6 were used to flare the coronal one-third of each canal to gain a direct access to the apex. Canals were irrigated with sterile saline during the access and flaring. The patency of the apical foramen was verified using 28 mm long # 20 flexofile.

The working length of all the 60 teeth was determined using four different systems:

1. Foramatron D10 (Parkell Dental, Farmingdale NY) [EAL]
2. Root ZX (J. Morita, Corp.) [EAL]
3. Radiovisiography (Eva)
4. Actual length by viewing under Operative Microscope (Seiler)

I.Measuring working length with apex locators

Electronic measurement was achieved using the Foramatron D-10 and Root ZX. For this, each sectioned tooth was mounted in alginate gel which was placed in a dappendish. The conductive gel (Alginate) simulates the periodontium. The teeth were kept in position until the alginate had set completely. Irrigation was done with 2-ml of 3% sodium hypochlorite (Vishal Dentocare PVT LTD). Cotton tips were used to dry the tooth surface and eliminate the excess irrigating solution. All measurements were made within an interval of 2 hours, while the gel was sufficiently humid.

1. Measuring working length using Foramatron d10

A flexofile (Dentsply, Maillefer) was attached to the file holder and was introduced into the canal. The lip clip was placed in the alginate gel to complete the circuit. When the file reached the apical constriction a ‘red’ mark blinked on the Foramatron D10 apex locator. This blinking indicated that the flexofile has reached the apical constriction. Now the silicon stopper was adjusted to the reference point as marked earlier on the cross section of the tooth. The file was then removed from the canal and measured with a digital caliper and its length was registered as the electronic length (EL) achieved with Foramatron.(**Fig.1)**

Fig.1. Working Length using Foramatron D10

Fig.2. Working Length Using Root ZX

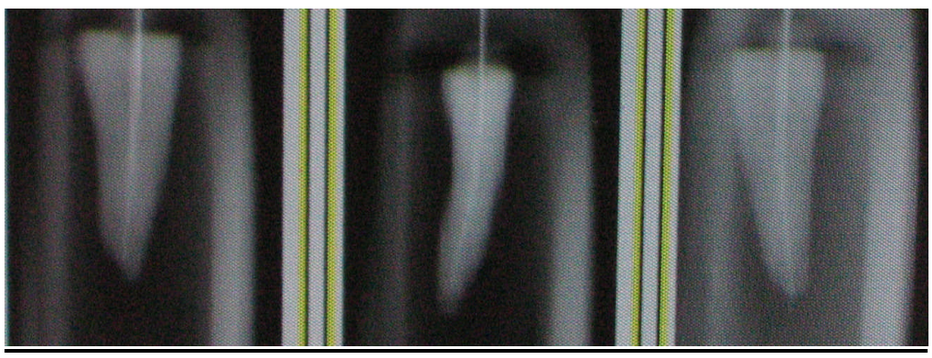


Fig.3. Working Length Using RVG

2. Measuring working length using root zx

The flexofile was attached to the appropriate electrode (file holder) of Root ZX apex locator and placed in the canal. The other electrode (lip clip) was attached to the conductive alginate gel. The apex locator was operated according to the manufacturer's instructions. The termination point used in this study was the red arrow on the meter designated by the manufacturer as the APEX. Now the silicon stopper was adjusted to the reference point as marked earlier on the cross section of the tooth. The file was then removed from the canal and measured with a digital caliper and its length was registered as the electronic length (EL) achieved with Root ZX**.(Fig.2.)**

II. Measuring working length using RVG

RVG consists of a hypersensitive sensor which is responsible for radiographic image that can be directly seen on the monitor. The teeth were held in small plastic containers and radiographic images were taken.**(Fig.3)**

Placement of teeth into the plastic container

Sixty plastic containers were used for 60 teeth. Each plastic container was filled with modeling wax in which the tooth was mounted. This set up gave a stable position to the tooth.

Stabilization of the hypersensitive sensor and plastic container set up

To prevent movement of the hypersensitive sensor a putty impression model was prepared which could stabilize the sensor while taking the images. Similarly, a model was prepared for the plastic container to stabilize it in the particular position in relation to the sensor. This set up gives a stable position to the particular tooth to take an image in the desired angulation. The radiographic cone was directed perpendicular to the setup while taking the images.

An Instrument (flexofile) was placed in the root canal of each tooth and three images were taken for each tooth to adjust and confirm if the file had reached the minor diameter. The position of the apex was confirmed on the monitor .The file was then removed and the length was measured using digital calipers.

The actual root canal length (AL) is the distance from the coronal reference plane to the apical constriction[1]. It was measured by inserting a flexofile into the root canal until the file tip was just visible at the level of the apical foramen. This procedure was done under the operating microscope at a magnification of X8 **(Fig.4 and fig.5)**. At this magnification the actual position of apical constriction was determined after introducing the file till the apical foramen and then readjusting to the apical constriction nearly 0.2 to 0.5 mm coronal to the apical foramen [6,7]. After adjusting the silicone stopper to the coronal reference, the file was removed from the root canal, and the distance between the file tip and the stopper representing the actual root canal length was measured using digital calipers.

Results

The present in vitro study was done to compare the efficacy of two apex locators (Root ZX and Foramatron D10) and Radiovisiography to determine the working length to that of actual lengths measured using operative microscope and the results obtained are tabulated (**Table 1)** The Analysis of Variance with Post Hoc test was used to compare the score between the rates **(Table 2** and **Table 3)**.

Fig.4. Operating Microscope Actual length

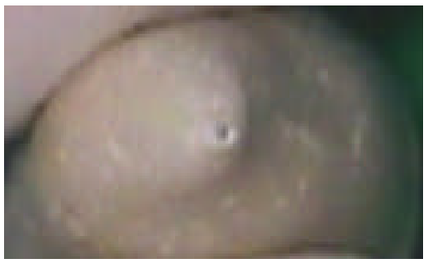
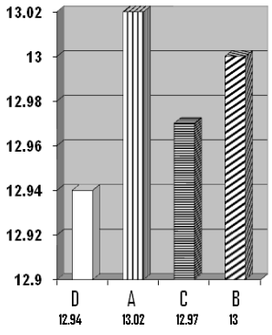


Fig.5. Apical Foramen under magnification X8

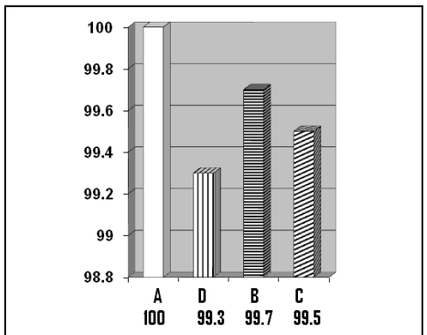
Discussion

The present invitro study was conducted in department of conservative dentistry and Endodontics to evaluate the efficacy of apex locators and RVG to determine working length in comparison with actual lengths. The mean values obtained by calculating the working lengths and actual lengths, the values for Actual length, Foramatron D10, Root ZX, RVG are 12.94, 13.02, 12.97 and 13.0 respectively.(**Graph-1).** In this study, the accuracy of working length for Foramatron D10, Root-ZX and Radiovisiography were 99.3, 99.7 and 99.5% respectively.(**Graph-2).**



Graph.1.Mean working length
A= Actual length ; B= Root ZX; C=Radio visiography ; D=Foramatron D10

Fernando Goldberg et al[8] concluded that electronic readings obtained with Root ZX showed an accuracy of 62.7%, 94.0%, and 100.0% within 0.5mm, 1mm, and 1.5mm, respectively, of the direct visual measurements. Fabio Luiz Cunha D' Assuncao et al[4] (2006) described that several in vitro researches have assessed the accuracy of the Root-ZX. Phillip B K and Subba Reddy V V[9] (1995) conducted a study found that the accuracy of Foramatron IV Digital Apex Locator was found to be **90%** including 20 cases (66.67%) that coincided with radiographic working length and 7 cases (23.33%) that were short of radiographic working length by 0.5mm. In this study, the accuracy of working length for Foramatron D10 is 99.3%. According to Randall Hedrick et al[10](1994) Anatomical measurements of true canal lengths for each canal was obtained by inserting a # 15K file in the canal to the major diameter *(apical foramen)* as observed under X8 microscope. The canal length was marked on the file shaft with a *new rubber stopper*.



Graph.2. Percentage of accuracy
A= Actual length ; B= Root ZX; C=Radio visiography ; D=Foramatron D10

Michelle A. Ellingsen, Lars G. Hollander et al[11] (1995) clinically compared Radiovisiography to conventional D. Speed and E- Speed radiographs in viewing size 8 and 10 Endodontic file tips in relation to radiographic apex in mesiobuccal roots of maxillary molars. Accurate identification of small file tips was achieved 95% on D. Speed, 70% on E-speed, 95% on 200 images in negative to positive mode, 86% of enhanced, 82% of standard 200m and 77% of images in negative to positive conversion with respect to Radiovisiography. In this study, the accuracy of working length for Radiovisiography is 99.5%. In the present study, the accuracy of working length for Foramatron D10, Root-ZX and Radiovisiography were 99.3, 99.7 and99.5% respectively. ANOVA and Post Hoc tests were used to analyze the data as the study included multiple comparisons. Statistically no significant difference (P>0.05) was detected, but Root-ZX seems to be more reliable for the determination of the working length.

The CDJ is a practical and anatomic termination point for the preparation and obturation of the root canal and this cannot be determined radio graphically.

Table 1. Descriptives

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
			Lower Bound	Upper Bound	Lower Bound	Upper Bound	Lower Bound	Upper Bound
Actual Length (mm)	60	12.94	2.47	.32	12.31	13.58	8.20	19.56
Foramatron D10	60	13.02	2.44	.32	12.39	13.65	8.29	19.56
Root ZX	60	12.97	2.45	.32	12.33	13.60	8.48	19.60
RVG	60	13.00	2.34	.30	12.40	13.60	8.18	19.24
Total	240	12.98	2.41	.16	12.68	13.29	8.18	19.60

Table 2. Post Hoc Test

(I) group(mm)	(J) group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
Actual Length	Foramatron	-.07483	.44290	.866	-.9474	.7977
	Root ZX	-.02317	.44290	.958	-.8957	.8494
	RVG	-.05467	.44290	.902	-.9272	.8179
Foramatron D10	Actual Length	.07483	.44290	.866	-.7977	.9474
	Root ZX	.05167	.44290	.907	-.8209	.9242
	RVG	.02017	.44290	.964	-.8524	.8927
Root ZX	Actual Length	.02317	.44290	.958	-.8494	.8957
	Foramatron D10	-.05167	.44290	.907	-.9242	.8209
	RVG	-.03150	.44290	.943	-.9040	.8410
RVG	Actual Length	.05467	.44290	.902	-.8179	.9272
	Foramatron D10	-.02017	.44290	.964	-.8927	.8524
	Root ZX	.03150	.44290	.943	-.8410	.9040

Table 3. ANOVA TEST

	N	Mean	Std. Deviation	F	P Value
Actual Length (mm)	60	12.94	2.47		
Foramatron D10	60	13.02	2.44		
Root ZX	60	12.97	2.45		
RVG	60	13.00	2.34		
Total	240	12.98	2.41	.011	.998 (NS)

NS-Not Significant

In an attempt to measure the working length to a value that almost coincides with the actual length or anatomic length and to overcome all the errors that could occur due to the limitation of the present techniques used, electronic apex locators with their inherent capacity to minimize the errors and the simplicity of the technique involved in the calibration of working length seems to be an important breakthrough in the field of Endodontics. Modern electronic apex locators can determine this position with accuracies of greater than 90% but still have some limitations. Knowledge of apical anatomy, prudent use of radiographs and the correct use of an electronic apex locator will assist practitioners to achieve predictable results.

The future of apex locators is very bright. Significant improvement in the reliability and accuracy of apex locators took place with the development of third generation models. It is probable that more dentists will now use apex locators in the management of Endodontic cases. The future apex locators should be able to determine working length in all electronic conditions of the root canal without calibration. The meter display on future apex locators should accurately indicate how many millimeters the instrument tip is from the apical constriction.

CONCLUSION

The following are the conclusions drawn from the present study: Electronic apex locators form an important adjunct in determining the working length. Working length determination with the Foramatron D10 is accurate but less accuracy than Root ZX and Radiovisiography. Working length determination with the Radiovisiography is also accurate but less than Root ZX and slightly higher than Foramatron D10. Root ZX is more accurate and effective for the determination of the working length in comparison with the other methods used in the present study.

References

1. John I. Ingle, Leif K. Backland, J. Craig Baumgartner, Allan G. Farman at al. Endodontics 6th ed BC Decker Inc. Hamilton. 2008. 2008: 573-89

2. Euiseong Kim, Seung-Jong Lee. Electronic apex locator. Dent Clin. N Am 2004; 48: 35-54.

3. Suzuki K. Experimental study on iontophoresis. J Jap Stomatol 1942; 16: 411-7.

4. Fabio Luiz Cunha D' Assuncao, Diana Santana de Albuquerque, Linalda Correia de Queiroz Ferreira. The ability of two apex locators to locate the apical foramen. In vitro study. J Endod 2006; 32(6): 560-2.doi:10.1016/j.joen.2005.11.011 PMid:16728251

5. Mears WA, Steiman HR. The influence of sodium hypochlorite irrigation on the accuracy of Root ZX electronic apex locator. J Endod2002; 28: 595-8.doi:10.1097/00004770-200208000-00008 PMid:12184422

6. Bregman Rc. Mathematical method of determining the length of a tooth for root canal treatment and filling. J Can Dent Assoc 1957; 16: 305.

7. Vande Voorde HE and Bjorndanl. Estimating endodontic working length with paralleling radiographs Oral Surg Oral Med and Oral Pathol Oral Radiol Endod 1969; 1: 106-10.

8. Fernando Goldberg, Ana C. De Silva, and Susana Manfre. In vitro measurement accuracy of electronic apex locator in teeth with simulated apical resorption. J Endod 2002; 28(6): 461-3. doi:10.1097/00004770-200206000-00011 PMid:12067130

9. Phillip B. K and Subba Reddy V.V. Comparision of root canal working length obtained by an electronic device with that of radiographic method: An in vivo study. Endodontol 1995; 7: 41-45.

10. Randall T. Hedrick Brent Dove, Donald D. Peters, William D. McDavid. Radiographic determination of canal length: Direct digital radiography versus conventional radiography. J Endod, 1994; 20(7):320-6.

11. Michelle A. Ellingsen, Lars G. Hollander et al. Radiovisiography versus conventional radiography for detection of small instruments in Endodontic length determination II. In vivo evaluation. J Endod 1995; 21(10): 516-20. doi:10.1016/S0099-2399(06)80525-X

Corresponding Author

Dr Ramesh T

Assistant Professor,
Department of Conservative Dentistry,
Government Dental College and Hospital,
Rajiv Gandhi Institute of Medical Sciences,
Kadapa. Andhra Pradesh, India.
Ph.No-91-944-047-2100
E-mail: ramesh2mds@gmail.com