

An *in vivo* comparative evaluation to determine the accuracy of working length between radiographic and electronic apex locators

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ABSTRACT

Background: An *in vivo* comparative evaluation to determine the accuracy of working length between radiographic and electronic apex locators.

Aim: The study was aimed at evaluating the accuracy of electronic apex locator, to determine the working length of root canal, and to compare it with the radiographic method of working length determination.

Materials and Methods: A total of 20 teeth selected for the study had to go for extraction because of periodontal or orthodontic reasons. Access cavity was prepared and the clinical estimated working length (CEWL) was determined with 10–25 no. K-file. A radiograph was then taken for determining the radiographic estimated working length (REWL). For electronic measurement of root canal, a 10 no. K-file was advanced toward the apex until it reached a 0.5 mm short of apex as shown by the apex locator. After fixing the file with a light cured composite, the tooth was extracted, the tooth surface was then longitudinally grounded using straight fissure diamond bur until the root canal and the tip of the file were visible. The distance of file from the minor constriction was measured with help of stereomicroscope.

Statistical analysis: The chi-square test was used for statistical analysis for this study.

Results: The chi-square test where $\chi^2 = 21.034$ with $P = 0.000$ indicated that a significant difference exists among the groups. The electronic method showed highest number of cases with the working length at the minor constrictor.

Conclusion: The electronic method for determining the working length of root canal was found to be more accurate than the radiographic method.

Key words: Electronic apex locator, radiographic method, working length

Received : 22-07-10
Review completed : 20-04-11
Accepted : 28-09-11

One of the most important steps of endodontic therapy is the determination of accurate working length, which is the distance from the coronal reference point to the point at which the canal preparation and obturation should terminate. Proper cleaning, shaping, and obturation of root canal are possible once the accurate working length is determined.

Various investigators have concluded that the most favorable prognosis was obtained when the procedure were terminated at the minor constriction and the worst prognosis when it extends beyond the minor constriction.^[1-3]

It is impossible on the radiograph to detect the major and minor foramina or cemento-dentinal junction.^[4-6] Although radiograph is routinely used to determine the working length, it has limitations as the apical foramen and apical constriction are usually not visualized in the radiograph;^[7] moreover, the position of the major apical foramen does not coincide with the root apex and may be located up to 2 mm away.^[8-10] Various other studies have also stated that the distance between the apical foramen and apical constriction may vary by 1 mm or more.^[11,12]

New instruments and equipment have since been developed to overcome the problem of determining accurate working length. Suzuki, in 1942, reported that the electric resistance between the periodontal ligament and oral mucosa was a

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Access this article online	
Quick Response Code: 	Website: www.ijdr.in
	DOI: 10.4103/0970-9290.102226

constant value of 6.5 k Ω ; however, it was in 1962 Sunada proposed the electric method of determining the apical foramen.

The advent of modern equipments has made work easier and less fatigue to patients and operators. In the new era, the electronic apex locator shows a promising future when used for the determination of accurate working length. Various generations of apical locator were developed for better accuracy, the latest being the fifth generation apex locator (Propex II, Dentsply), which is a multifrequency-based apex locator.

This study was carried out to evaluate the accuracy of electronic apex locator (Propex II, Dentsply) in determining the working length of root canal and comparing it with the radiographic method of working length determination.

MATERIALS AND METHODS

A total of 20 patients were selected from the outpatient department of D.A.V. (C) Dental College and Hospital, Yamuna Nagar, Haryana (India). The patients selected for the study included 11 males and 9 females, aged between 25 and 55 years old. The study included those teeth that had to go for extraction because of periodontal or orthodontic reasons; moreover, the teeth that were selected for the study had:

- No apical resorption, fracture or open apices.
- No calcification in the root canal.
- No metallic restoration.
- Patients with pacemakers were excluded in the study.

The patient's consent was taken before the start of the study from each patient. The nature of the procedure and the discomfort involved were fully explained. Complete medical and dental history was obtained.

A preoperative periapical radiograph (Kodak, dental intra oral E- speed film) was taken with 65 kV, 8 mA (Gnathus, Japan). Local anesthesia (Lignox 2%, Indoco Remedies Ltd.) was administered and access cavity prepared using straight fissure diamond bur in a high speed contrangle hand piece under water spray.

The root canals were irrigated with 2.5% sodium hypochlorite solution and excess of irrigant was removed from the pulp chamber with the help of cotton pellet, without drying the root canal. The clinical estimated working length (CEWL) was determined with 10–25 no. K-file (Mani, Japan) depending upon the size of the canal. A radiograph was then taken keeping the file at the same CEWL for determining the radiographic estimated working length (REWL). The working length was then adjusted, and another radiograph was taken for determining the

operator-adjusted radiographic working length (OPARWL), 0.5 mm short of apex was considered as accurate. Propex II (Dentsply) was used for electronic measurement of root canal. The lip clip (contrary electrode) was placed in the corner of the patients' mouth, and the file holder was attached onto the shaft of the file. The apical foramen was located by advancing a 10 no. K-file toward the apex. The file insertion was stopped when the meter flashed and an audible signal indicated that the foramen has been reached (0.5 mm marking just before the apex was selected for termination). The light cured composite (Charisma, Germany) was used to fix the file at the measured working length. The file handle and the exposed shaft were separated using a high speed handpiece. The Propex II electrode was again placed against the residual shaft of the file to verify that the meter recording had not changed. The tooth was then extracted, cleaned, and the apical foramen was marked with permanent ink with the help of operating microscope (Denfort International, India). The tooth surface was longitudinally ground using straight fissure diamond bur until the root canal and the tip of the file were visible. The distance between the coronal reference point and the apical constriction was measured with stereomicroscope (Almicor zoom stereoscopic binocular microscope, India) as shown in Figures 1 and 2. Thus, the actual anatomic working length (i.e. from the coronal reference points to minor constriction) and electronic estimated working length (using Propex II) were determined as shown in Tables 1 and 2.

Statistical analysis

The χ^2 -square test was used for statistical analysis in this study.

RESULTS

The electronic method as shown in Table 3 showed highest number of cases of 75% accuracy of working length at the minor constrictor, 20% short, and 5% beyond the minor constrictor, whereas the CEWL as shown in Table 2 showed 25% accuracy of working length at the minor constrictor, 45% short, and 30% beyond the minor constrictor. The least accuracy of working length was observed with operative adjusted working length using the radiographic method, in which only 10% accuracy of working length at the minor constrictor, 45% short, and 45% beyond the minor constrictor. The χ^2 -test where $\chi^2 = 21.034$ with $P = 0.000$ as shown in Table 4 indicated that a significant difference exists among the groups, since the P value is less than 0.01.

DISCUSSION

Working length is defined in the Endodontic Glossary as "the distance from the coronal reference point to the point at



Figure 1: Tooth specimen being examined under stereomicroscope.

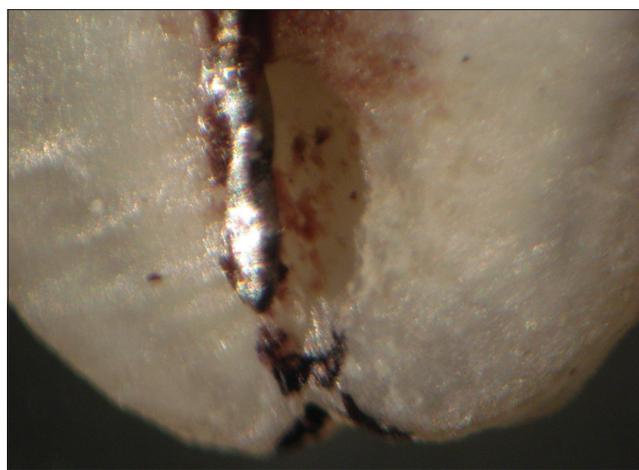


Figure 2: Tooth specimen being examined under stereomicroscope showing major and minor constrictors with a K-file placed in the root canal.

Table 1: Master chart of working length using different techniques

Case no.	CEWL (in mm)	Radiographic interpretation (RI)	EEWL (in mm)	AAL from apical constriction (in mm)	OPARWL (in mm)	Error in radiograph (distance from minor constriction) (in mm)	Error in apex locator
1.	20.5	0.5 mm short at apex	20.0	20.0	20.5	0.5 mm beyond	
2.	18.5	At apex	18.5	18.5	18.0	0.5 mm short	
3.	23.0	1.5 mm short of apex	23.5	23.5	24.0	0.5 mm beyond	
4.	20.0	1 mm short of apex	20.5	21.0	20.5	0.5 mm short	0.5 mm short
5.	19.5	At apex	19.5	19.5	19.0	0.5 mm short	
6.	22.0	1.5 short of apex	22.5	22.5	23.0	0.5 mm beyond	
7.	21.5	0.5 mm overinstrumented	20.0	20.0	20.5	0.5 mm beyond	
8.	18.0	At apex	18.0	18.5	17.5	1 mm short	0.5 mm short
9.	20.0	0.5 mm short	21.0	20.0	20.0		1 mm beyond
10.	20.0	1.5 mm short of apex	20.5	21.5	21.0	0.5 mm short	1 mm short
11.	18.5	0.5 mm short	18.0	18.0	18.5	0.5 mm beyond	
12.	22.0	1.5 mm short	22.5	22.5	23.0	0.5 mm beyond	
13.	21.5	At apex	21.5	21.5	21.0	0.5 mm short	
14.	23.5	0.5 mm overinstrumented	22.0	22.0	22.5	0.5 mm beyond	
15.	19.0	At apex	19.0	19.5	18.5	1 mm short	0.5 mm short
16.	22.0	0.5 mm short	22.5	22.5	22.0	0.5 mm short	
17.	21.5	0.5 mm overinstrumented	20.0	20.0	20.5	0.5 mm beyond	
18.	20.0	At apex	20.0	20.0	19.5	0.5 mm short	
19.	20.5	At apex	20.0	20.0	20.0		
20.	22.0	1.5 mm short	22.5	22.5	23.0	0.5 mm beyond	

Table 2: Number of cases and its corresponding distance from the minor constriction

Distance	CEWL, n= 20	OPARWL, n = 20	Apex locator EEWL, n = 20
At minor constriction	5	2	15
Short from minor constricator	9	9	4
Beyond minor constricator	6	9	1

Table 3: Percentage of sample units from minor constriction

Distances	Various methods of working length determination		
	CEWL, n = 20 (%)	OPARWL, n = 20 (%)	Apex locator EEWL, n = 20 (%)
At minor constriction	25.0	10.0	75.0
Short from minor constricator	45.0	45.0	20.0
Beyond minor constricator	30.0	45.0	5.0
Total	100.0	100.0	100.0

which canal preparation and obturation should terminate.” The minor constriction or apical constriction (minor apical diameter) is the apical portion of the root canal having the narrowest diameter.

An accurate working length determination is a critical factor in the success of root canal treatment. Studies by Stavrianos *et al.*,^[13] have shown that the latest generation electronic apex locator would accurately determine the working length

Table 4: Chi-square test

	Value	df	Asymp. sig. (two-sided)
Pearson chi-square	21.034	4	0.000

from 75% to 96.5% of the root canal with mature apex. Our study corresponds with their study, and found the accuracy of electronic apex locator to be around 75% when measured at the minor constrictor and the accuracy increased to 90% when the working length was considered at or 0.5 mm short of minor constrictor.

The accuracy when using the radiographic method was least with 10% when considering 0.5 mm short of apex and accuracy increased to 45% when the working length was considered at or 0.5 mm short of the minor constrictor. In this study, the CEWL taken by the operator showed 25% accuracy at the minor constrictor and when considering 0.5 mm short of the minor constrictor the accuracy increased to 60% thereby showing more accuracy than the OPARWL taken by the operator using a radiographic method of working length determinations.

The frequency of OPARWL measurement that passed beyond the minor constrictor was 45% where as the CEWL showed 30% over instrumentation, which was less than the OPAWL taken by the radiographic method, this may be because the operator tends to adjust the working length as per the radiographic apex; moreover, studies by Kuttler^[8] have observed that the apex and apical foramen coincide only in less than 50% of cases and are located short of apex on the facial and lingual aspects of the root, resulting in over instrumentation, thus limiting the use of radiography

Only 5% showed over instrumentation when using the electronic apex locator (electronic estimated working length, EEWL) this may be due to the error of reading using proper II.

Radiography provides vital information of the root canal anatomy, its size, canal curvature, and the number of roots; it provides information of exit of the root canal from the floor of the chamber. However, there are certain disadvantages of radiographs as it only provides a two-dimensional image of a three-dimensional structure, and it is difficult to locate the exact location of the apical foramen; moreover, it was impossible to detect the major or minor foramina or the cemento-dentinal junction;^[14,15] It provides little or no information of the curvature of the root in the plane of the film. Moreover, at times it becomes difficult to visualize root canal files because of dense bone and anatomical structures like zygomatic process.

The apex locators have certain disadvantages such as inaccurate length measurement because of dentinal debris, calcifications, and lack of patency; moreover, the presence of intact vital tissue, inflammatory exudate, and blood can

conduct electric current giving inaccurate readings. Short-circuiting of the apex locator can occur because of metallic restorations, caries, saliva, and instruments in the second canal. In spite of all these, apex locators reduce the number of radiographs required, have minimum exposure and more accurate determination of working length and are useful in pregnant patients; they are also useful in patients with gag reflex and in cases where exposure and interpretation with radiographs become technique-sensitive.

CONCLUSION

Our study concludes that the electronic apex locator to be more accurate than the radiographic method. However, it is important to combine and take the advantage of both the electronic and radiographic methods to achieve more accurate results in determining the working length of root canal.

REFERENCES

- Burch JG, Hulen S. The relationship of the apical foramen to the anatomic apex of the tooth root. *Oral Surg Oral Med Oral Pathol* 1972;34:262-8.
- Chapman CE. A microscopic study of the apical region of human anterior teeth. *J Br Endod Soc* 1969;3:52-8.
- Czerw RJ, Fulkerson MS, Donnelly JC, Walmann JO. In vitro evaluation of the accuracy of several electronic apex locators. *J Endod* 1995;27:572-5.
- Dummer PM, McGinn JH, Rees DG. The position and topography of the apical canal constriction and apical foramen. *Int Endod J* 1984;17:192-8.
- Weine FS. *Endodontic Therapy*. 6th ed. Calculation of working length. Noida, Uttar Pradesh, India: Mosby; 2004. p. 240-65.
- Green D. A stereomicroscopic study of the 700 root apices of 400 maxillary and mandibular posterior teeth. *Oral Surg Oral Med Oral Pathol* 1960;13:728-33.
- Green D. A stereomicroscopic study of the root apices of 400 maxillary and mandibular anterior teeth. *Oral Surg Oral Med Oral Pathol* 1956;9:1224-432.
- Kuttler Y. Microscopic investigation of root apices. *J Am Dent Assoc* 1955;50:544-52.
- Lambjerg-Hansen H. Vital and mortal pulpectomy on permanent human teeth: An experimental comparative histologic investigation. *Scand J Dent Res* 1974;82:223-332.
- Mayeda DL, Simon JH, Aimer DE, Finley K. In vivo measurement accuracy in vital and necrotic canals with the Endex apex locator. *J Endod* 1993;19:545-8.
- Cohen S, Hargreaves KM. *Pathways of pulp*. 9th ed. Tooth morphology and access cavity preparation. New Delhi, India: Mosby; 2005. p. 148-232.
- Ricucci D, Langeland K. Apical limit of root canal instrumentation and obturation. Part 2.A histological study. *Int Endodontic J* 1998; 31:394.
- Stavrianos C, Gogos C, Vasiliadis L, Economides N. Clinical comparative evaluation of the accuracy of the electronic apex locators Root ZX, Justy II in the working length measurement of 50 single rooted teeth. *Balk J Stom* 2003;7:30-2.
- Tselnik M, Baumgartner JC, Marshall JG. An evaluation of Root ZX and element diagnostic apex locators. *J Endod* 2005;31:507-9.
- Verturi M, Breschi L. A comparison between two apex locators: An in vivo investigation. *Int Endod J* 2005;38:36-45.

How to cite this article: Singh SV, Nikhil V, Singh AV, Yadav S. An in vivo comparative evaluation to determine the accuracy of working length between radiographic and electronic apex locators. *Indian J Dent Res* 2012;23:359-62.
Source of Support: Nil, **Conflict of Interest:** None declared.