IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 24, Issue 7 Ser. 6 (July. 2025), PP 26-31
www.iosrjournals.org

Accuracy Of Cone-Beam Computed Tomography And Electronic Apex Locator In Determining Working Length In Open Apex Teeth: A Clinical Study

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Abstract:
Background*: Endodontic therapy has a high success rate when performed with proper debridement and accurate obturation. While electronic apex locators (EALs) are effective in determining working length (WL), their reliability is compromised in cases with open apices. Therefore, this study aims to compare the accuracy of working length determination in open apex cases using electronic apex locators and cone-beam computed tomography (CBCT)*
Materials and Methods*: A total of 36 paediatric patients, aged between 6 to 10 years, with teeth having open apex indicated for endodontic and regenerative procedure were encompassed in this research. These patients had been then separated into 2 groups to determine the working length following access opening and proper debridement. In group I CBCT (NNT software) was used, in which digital ruler had been utilized to measure the distance from occlusal reference point to the apex. In group II apex locator (IPEX II), was placed and a digital reading was obtained. The recorded data was statistically analysed utilizing Social Sciences (SPSS 23 version) (IBM Corp., Armonk, NY).*
Results*: Working length using the EAL (electronic apex locator) was substantially shorter than that of the CBCT.*
Conclusion: *CBCT was more comfortable and gave accurate results as compared to IPEX II apex locator.*
Key Word: *Immature permanent teeth, Cone-beam computed tomography (CBCT), Electronic apex locator (EAL)*

Date of Submission: 10-07-2025 Date of Acceptance: 20-07-2025

I. Introduction

The apical foramen undergoes anatomical modifications as a tooth erupts in the oral cavity, despite the fact that root development is yet incomplete. The apical closure occurs 3years following tooth eruption, marking the end of root growth.[1] In between, if any trauma or else injury occurs before apical closure, the root growth disrupts leading to the open or immature apex.[2]

According to Gill et al, there exist 2 kinds of open apices: blunderbuss along with non- blunderbuss apices.[3] While the canal walls of a non-blunderbuss apex might be parallel or partially convergent, that causes a wide or else convergent apex, the walls of the blunderbuss apex diverge and the apex expands out in a funnel form.[3]

The lack of a tapering root canal apical closure, the existence of thin, brittle radicular walls, mechanical preparation, along with canal disinfection can all make treatment an immature permanent tooth having with a blunderbuss canal problematic.[4]

There are various conventional methods available to take the WL with more accuracy in open apex; but the disadvantages are large inter-operative differences in the measurement, difficulty in disengaging file tip from the dentinal wall, large contact area of the paper point to the periapical tissues and the presence of excess moisture. These techniques lead to measurement error.[5] To overcome these errors, there is a need for better technique in determination of WL in immature open apices.

EALs are often used in open apices to measure the working length (WL) but measurements can be either beyond the apex or shorter due to which EAL give non reliable results in teeth with open apices.[6] In situations of infection, the apical tissues may be crucial, and a short Working Length is unlikely to have an impact on the

course of treatment. Also, Negative outcomes could result if the necrotic, diseased tissues have been kept in the apical region.[7]

For these reasons, a most recent, accurate and advance procedure is required which will give more reliable results in determination of Working Length.

CBCT (Cone-Beam Computed Tomography) is a significant technological advancement in dentistry that has great potential for clinical use and accuracy. It captures the image in 3-D plane and give the mean of all these planes. Also, a useful substitute for measuring WL in teeth that have an open apex.[2]

In numerous researches has been carried out on the comparison of working length determination but none of the clinical studies can be traced which have tried to estimate the relative effectiveness of accuracy in WL determination in immature open apices.

For the purpose to examine the accurateness of CBCT in addition to EAL in computing the WL in open apices, the current study has been developed.

The null hypothesis suggested that the accuracy of determining WL (working length) utilizing CBCT in open apex and EAL was the same.

II. Material And Methods

This current research was approved by the Institutional Ethical Committee (GDC/ Perio/ ethical committee/1703) study had been carried out in accordance with the existing norms and regulations. The study acquired the working length by using IPEX II AND CBCT (NNT software) in immature apex obtained from patients of aged between 6- 10 years reported in the Department of Paediatric & Preventive Dentistry, Srinagar Jammu and Kashmir.All study participants provided informed consent.

Study Design: Prospective study

Study Location: The study was conducted on 36 pediatric patients who reported to the Department of Paediatric and Preventive Dentistry, Government Dental College, Srinagar, Jammu and Kashmir.

Study Duration: August 2023 to October 2023.

Sample size: 36 Paediatric patients

Sample size calculation: A sample size calculation was conducted using G*Power software (version 3.1.9.2) for an independent t-test with a two-sided significance level of 0.05 and power of 0.80. Based on the observed means and standard deviations (CBCT: 18.908 ± 2.24; EAL: 18.474 ± 2.30), the calculated effect size (Cohen's d) was 0.19. To detect this small effect, a sample size of 866 participants (433 per group) would be required. However, due to practical and ethical limitations, a sample size of 36 (18 per group) was chosen, which is more appropriate for detecting moderate to large effects in a clinical setting.

Subjects & selection method: A total of 36 paediatric patients with open apex in posterior teeth were included which were further divided equally into two groups (Group I &II).
Group 1 (18)- paediatric patient that were subjected to identify the WL by utilizing CBCT (NNT Software)
Group 2 (18)- paediatric patients were subjected to identify the WL by utilizing Apex Locator (IPEX II).

Inclusion criteria:
1.Open apex teeth indicated for endodontic procedure.
2 Patients indicated for regenerative procedure.

Exclusion criteria:
1.Root resorption
2.Teeth with calcifications
3.Teeth fractures
4. Root caries.

Procedure methodology

Local anaesthesia concentration of 2% lidocaine with adrenaline was administered and the teeth were isolated by using rubber dam. Carious portion was removed, Access Cavity were prepared by using round bur (Mani Endo Access Diamond Burs EA025, Dentalkart) and was further refined by using Endo Z bur (Endo-Z Tungsten Carbide Burs, Dentalkart) The root canal were thoroughly irrigated by utilizing (5ml of 5%) Sodium hypochlorite along with (17%) EDTA, Saline during the procedure and canals were dried by using paper point

for 60 seconds. For pulp extirpation, H shape hand file was used, the WL (Working Length) had been established by:[1]

Group 1- CBCT – NNT software was used. Using the appropriate software tools, the 3-D picture of the tooth was first separated from the surrounding structure. The operator verified the apex foramen and canal orifice for every tooth's canal. Software would consequently create a line connecting these two landmarks instantly as they were defined, this length had been recorded as 3D-WL by using digital ruler (Figure 1).[8]

Group2- Electronic Apex Locator- As directed by the manufacturer instrumentation working length was determined using IPEX II. Inside the root canal, the apex locator's electrode was attached with a stainless steel file, lip clip had been connected to patient's lip. File was displayed up until the point when the IPEX II display indicated the AF as green signal. After that file had been remove and use a digital calliper to take 1 mm away from the initial measurement (Figure 2).[9]

Statistical analysis

The data had been analysed by utilizing Social Sciences (SPSS 23 version) (IBM Corp., Armonk, NY). Shapiro Wilk test had been utilized for verifying whether normal distribution had been all followed by all variables. Non-parametric tests, that includes the Wilkson signed ranked t test, were employed for bivariate analyses, with a level of significance of p less than 0.05.

III. Result

Statistical analysis had been done with significant difference of p less than 0.05. Accuracy of Working Length measured with Electronic Apex Locator was significantly low as compared to CBCT (Table 1).

Outcome of the study indicate that Group 1 CBCT revealed maximum significant difference in contrast with study Group 2 Electronic Apex Locator (Table 2). The bar chart illustrates that Group 1 (CBCT) demonstrated significantly greater accuracy in working length determination compared to Group 2 (Electronic Apex Locator) (Figure 3).

Table 1 presents the intergroup comparison of working length measurements obtained using the Electronic Apex Locator and CBCT. The mean working length recorded by the CBCT group was **18.908 mm** with a standard deviation of **2.2449**, while the Electronic Apex Locator group showed a lower mean working length of **18.474 mm** with a standard deviation of **2.3050**. Statistical analysis revealed a **significant difference** between the two groups (**P = 0.001**), indicating that CBCT provides significantly greater accuracy in determining working length compared to the Electronic Apex Locator.

Table no 1: Intergroup comparison between Electronic Apex Locator and CBCT

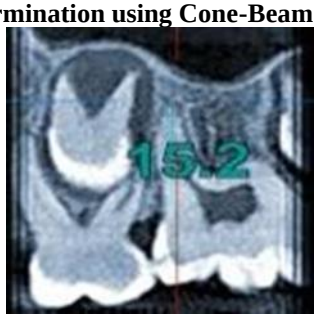
		N	Mean	Std. Deviation	P value
GROUPS	ELECTRONIC APEX LOCATOR	18	18.474	2.3050	0.001*, sig
	CBCT	18	18.908	2.2449	

Table 2 displays the paired differences in working length measurements between CBCT and Electronic Apex Locator. The mean difference between the two methods was **–0.4337 mm**, with a standard deviation of **0.2350 mm**. The 95% confidence interval ranged from **–0.5109 to –0.3564**, confirming the consistency of the observed difference. The difference was **statistically significant** with a **P-value of < 0.001**, indicating that CBCT consistently measured a longer and potentially more accurate working length compared to the Electronic Apex Locator.

Table no2 : **Mean difference between Electronic Apex Locator & CBCT**

		Paired Differences					Df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference			
					Lower	Upper		
GROUPS	ELECTRONIC APEX LOCATOR & CBCT	-.4337	.2350	.0381	-.5109	-.3564	37	.000

Figure(1): Working Length Determination using Cone-Beam Computed Tomography (CBCT).

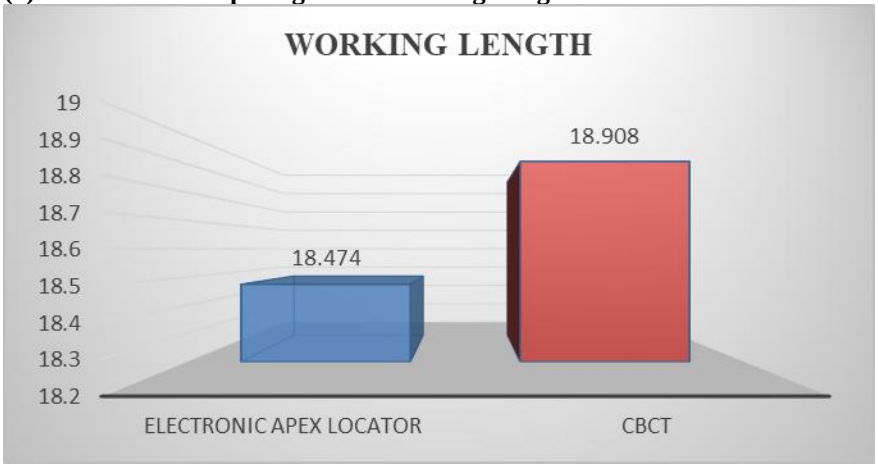


3D reconstructed image obtained through NNT software showing measurement from the occlusal reference point to the radiographic apex using a digital ruler.

Figure(2): Digital Reading from Electronic Apex Locator

The IPEX II display indicates the apical foramen (AF) with a green signal at 0.4, confirming the file position for working length determination.

Figure(3): Bar Chart Comparing Mean Working Length Determination Between Groups.



Bar chart comparing the mean working length determination between groups. Group 1 (CBCT) demonstrated a significantly greater mean working length (18.908 mm) compared to Group 2 (Electronic Apex Locator) (18.474 mm). Error bars represent standard deviation. The difference was statistically significant ($P < 0.05$).

IV. Discussion

Precise WL determination is a crucial component of an efficient endodontic treatment, among many additional crucial factors.[10] Ng Y.-L et al has revealed in his Epidemiological study that excellent control of WL is a requirement for a favorable endodontic consequence.[11]

Because of pulp necrosis caused through trauma or else caries, an open apex may persist during the stage of development. It can also be caused by iatrogenic means, such as excessive instrumentation or root excision. It retains an extraordinarily wide foramen, making obtaining an apical stop challenging.[2]

Even if the primary method to select WL for treating teeth with open apices is radiography.[12] In 1957, Ingle's method indicated that a pre-operative radiograph or else tactile technique was employed to estimate the radiographic working length 1mm to 2mm short of the radiographic apex. In the year 1970, Van Hassel and Natkin discovered that instrumentation had been utilized to the radiographic apex when treating immature permanent teeth with open apices.[12] Various reports that are in Frank study done in 1966 and Sarris et al. (2008) Yassen et al. (2012) discussed utilization of radiography for determination of WL but did not provide any further information.[12] In 2001, Whitworth and Nunn proposed that the canals be prepared 2-3 mm shorter than the predicted WL derived from the undistorted pre-operative periapical radiograph.[12]

Suzuki et al has mentioned the disadvantages of the radiographic approach include increased exposure in the radiation, time consumption, in maximum instances, the cement-dentinal junctions that, because of cementum deposition, they fail to line up with the spot 0.5mm below the radiographic apex.[13] Additionally, it can provide a 2D image and provides accurate information on radiography apex's location.[13]

To overcome the limitations of the radiography approach, three-dimensional views and electrical devices (EALs) for WL determination are becoming progressively common. Examining the accurateness of CBCT and EAL, that are frequently employed in clinical practice, was the primary goal of this investigation.

According to Kobayashi C et al. (1994), Root ZX is gold standard by which the most recent EALs have been evaluated and is a most widely investigated EALs [14]. Research has indicated that its precision ranges from 50% to 100%.[14]

El Ayouti et al. identified that Root ZX had been precise and that, in simulated open apex, the length measurements acquired with both large along with small size files were similar.[15] They discovered, however, when blood is presence, this accurateness with the small K file sizes, such as #15, is not attained, which may have an impact on few factors in the electronic root length estimation method.[15] According to a 1996 study by Ngyungen et al., the size of file had no influence on the precision of EAL measurements.[16] In our study, the measurement was practical and repeatable with inserted instrument. According to Berman LH et al. and Hulsman M et al., the WL determination utilizing EAL produces less reliable findings when the apical foramen is big or else immature.[17]

As per an investigation by Gordon MP et al. (2004), the fourth-generation apex locator (I PEX II) was utilized in this investigation because it enhances measurement accuracy and reliability by utilizing just one frequency at a certain time as well as basing measurements on the RMS (root mean square values) of signal frequency.[18]

According to in vivo as well as ex vivo investigations published in literature, Kumal LV et al. and Beltrame AP et al. found no discernible difference among EAL and other AL (actual length) evaluation techniques for example direct visual, direct visual with magnification, along with stereomicroscope approaches.[19,20]

Because CBCT is quite accurate at determining WL as well as produces undistorted images, it was employed in our investigation with adequate voxel size to represent actual root length. In both the maxilla and mandible, CBCT continuously showed great accuracy in working length estimation across a variety of tooth forms. Because of its dependability and accuracy, CBCT has become a powerful tool in endodontics, producing three-dimensional, distortion-free pictures that are essential for accurate working length measurement.[21]

When we compare our findings to the current literature, we see that they are consistent with studies that emphasise CBCT's high accuracy across diverse tooth kinds.[22] Variability in the EAL accuracy, consistent with earlier research, which emphasis the impact of canal morphology, type of the tooth, and diseases on EAL accuracy. The combined evidence adds to a better knowledge of CBCT and EAL in endodontics, recognising the importance of continual advancement in procedures and technologies.[23]

To obtain CBCT measurements, Connert et al. drew a single line across the cusp tip along with the foramen.[24] The curved canals were drawn by Lucena et al. utilizing a multiple-line tracing technique.[23] More precise outcomes may be obtained by following the canal line with many lines, as per Connert et al.[24]

In this current investigation mean difference between CBCT and EAL significant ($p<0.001$) (Table 1) with the mean difference of 0.4 on intergroup comparison (Table 2).

Hence, CBCT could be use an alternative to EAL for determination of WL in open apex.

Limitation of this research was that the CBCT was quite expensive. Future research can concentrate on employing a technique that will be more accurate and less expensive.

V. Conclusion

Fourth generation apex locator has outperformed more accurately amongst all the apex locator. CBCT a 3D scanner viewer gains the advantage for the clinician to identify the working length in open apex more precisely than apex locator.

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