

# Evaluation of the Working Length Determination Accuracy by Cone-beam Computed Tomography in Primary Teeth

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## ABSTRACT

**Background:** In primary teeth, working length determination is complicated due to its continuous alteration in dimension, shape, and root apex position. Accurate working length determination is essential to achieve the optimal cleaning and disinfection of the canal. Despite the use of conventional radiographic method, newer methods are available to increase the accuracy of WL determination. This study aims to compare electronic apex locator (EAL) with radiographic method of WL determination and to evaluate its accuracy using cone-beam computed tomography (CBCT).

**Materials and methods:** Sixty root canals from 34 extracted primary teeth were included. Occlusal surfaces were flattened and access opening done for all the samples. Teeth were subjected to working length determination by conventional radiograph and EAL. Samples were then mounted on a U-shaped wax and subjected to CBCT. Results were recorded and statistically analyzed using ANOVA and ICC for quantitative data.

**Result:** The mean measurement of radiographic, EAL and CBCT methods are 11.708, 11.200, and 10.895, respectively. Mean measurements demonstrated significant difference ( $p < 0.05$ ) between three methods. ICC demonstrated high correlation between EAL and CBCT with Cronbach's  $\alpha$  value of 0.962 and moderate correlation were observed between radiographic method and CBCT (0.706) and EAL and radiographic method (0.763). EAL demonstrated 87% accuracy whereas radiographic method demonstrated 63% accuracy to the actual length as evaluated by CBCT.

**Conclusion:** EAL is more accurate than conventional radiographic method as evaluated by CBCT.

**Keywords:** Electronic apex locator, Primary teeth, Pulpectomy, Working length.

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## INTRODUCTION

A major goal of treating young patients is to maintain the integrity of primary dentition till its physiologic exfoliation.<sup>1</sup> Pediatric endodontics deals with the management of pulpally involved primary and young permanent teeth in children.<sup>2</sup> Patient's cooperation, limited access, anatomical variations, and complex anatomy of the primary roots makes the treatment difficult.<sup>3</sup> The most important factor for the success of pediatric endodontics is to decide the extent of instrumentation and to what point the obturation should end.<sup>4</sup>

The traditional methods of working length determination in primary teeth are looking for the presence of moisture/blood at the tip of the paper point, relying on tactile sensation to feel the apical constriction and knowledge of the average length of tooth.<sup>1</sup> Ingle's radiographic method is one of the most common and reliable methods used in determining the working length.<sup>5</sup> But the technique has some disadvantages and limitations, such as limited access to the mouths of young children, poor patient cooperation, increased appointment time, and exposing the children to ionizing radiation. As the radiographic image is bidimensional and the tooth and periradicular area are three-dimensional, there might be distortions and errors in the evaluation of WL measurements, and at times the major foramen or apical constriction position can go undetected.<sup>6</sup>

Limitations of radiograph technique was overcome by the invention of electronic apex locator (EAL) which has a higher accuracy than that of the conventional radiograph. They work on the electrical resistance that is demonstrated by the apical foramina instead of visual inspection.<sup>7</sup> Over a period of time, generations of EAL devices were evolved with each generation overcoming the shortcomings of the former generation. The fifth generation apex locator overcomes the limitation of the fourth generation, such

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that it can function efficiently even in the presence of the blood and exudate.

The methods to determine the accuracy of radiographic technique and EAL are by Stereomicroscope and cone-beam computed tomography (CBCT). The CBCT is the advanced imaging technique with high potential in clinical application and improved accuracy in treatment planning. The most important advantages of CBCT are relatively low radiation dose and less exposure time than the conventional computed tomography. Overlapping problems inherent with the conventional periapical radiographs can be overcome with the CBCT. Therefore, this research aims to compare the radiographic and EAL method of WL determination in primary teeth and to evaluate accuracy using CBCT.

## MATERIALS AND METHODS

The research was performed in the Department of Pediatric and Preventive Dentistry. The study was approved by Institutional Ethical Committee (XXXXXX).

The study included 43 extracted primary teeth that are retained, nonrestorable and the teeth with not more than 1/3rd apical root resorption. To rule out any calcified canals or perforation or any remnants of obturated material, radiograph of the extracted tooth were taken. Finally, 60 root canals were included from 34 extracted primary teeth.

The occlusal surface of the teeth was flattened to create a defined reference point, that is, 3 mm from CEJ occlusally. Access cavity preparation was done using a round diamond bur under abundant water spray. Pulpal tissue of each tooth was extirpated using a 21 mm long H file. The pulp chamber was dried using absorbent points. As per Ingle's method of working length determination, WL was determined for the selected canals, files were inserted and a conventional radiograph was made (Fig. 1).

Working length determination by using EAL was carried out following the conventional radiographic method. In order to simulate clinical environment of PDL the teeth were mounted in container filled with alginate. The fifth generation apex locator (Woodpex III) was used in this study. The file (K-files #15, 21 mm in length) was attached to the file holder and the lip hook was attached to alginate material. Alginate was chosen, as the electrical conductance of alginate and PDL is same. The file was advanced till the device indicated 0.0 mark. The rubber stop was moved to the occlusal reference edge and the file was removed. The distance between the rubber stopper and the file tip was measured using the Endo gauge.

The teeth were then mounted in a U shape wax pattern for CBCT analysis. CBCT images was acquired with Vatech 3D imaging system. The tube voltage was 85 Kvp and the tube current was 4.5 mA with the exposure time of 9 seconds. The voxel size was 0.0 mm (thickness of the slice of the image) and the Field of View was 80 × 80 mm. The buccolingual and the mesiodistal section of every teeth was recorded and the root length was measured in the software (Ez3Di) (Fig. 2). Data obtained were entered in excel sheet and subjected to statistical analysis.

## RESULTS

The mean working length measurements by radiographic method, EAL and CBCT are 11.708, 11.200, and 10.895 (Table 1). It demonstrated a significant difference between the three techniques ( $p < 0.05$ ).

*Post hoc* analysis was carried out to assess the difference between each technique. Analysis revealed that there was no

statistically significant difference between EAL and Radiographic determination ( $p = 0.343$ ) and also between EAL and CBCT ( $p = 1.0$ ). This implies that the measuring accuracy of CBCT and EAL were similar. But, a statistically significant difference was observed between Radiographic method of determination and CBCT method  $p = 0.036$ .

When 18 anterior canals and 42 posterior canals was evaluated, anterior teeth canals demonstrated insignificant difference ( $p = 0.06$ ) between the techniques whereas posterior teeth demonstrated significant difference ( $p = 0.029$ ) in the mean working length measurements.

The correlation between each technique have been assessed using Intraclass Correlation Coefficient (ICC), the high correlation and agreement were observed between EAL and CBCT with Cronbach's  $\alpha$  value = 0.962. When Radiographic method and CBCT technique were assessed by ICC, it demonstrated moderate correlation and substantial agreement with Cronbach's  $\alpha$  value = 0.706. The ICC correlation between EAL and Radiographic technique demonstrated moderate correlation and substantial agreement with Cronbach's  $\alpha$  value = 0.763.

Regression analysis was done to evaluate the accuracy of EAL and radiographic method. EAL demonstrated about 87% accuracy of CBCT values (Table 2) whereas radiographic method demonstrated 63% of accuracy in predicting the CBCT technique (Table 3).

## DISCUSSION

One of the key factors for the success of endodontic treatment in primary teeth is determining the accurate working length of the tooth which is essential for preventing over instrumentation, thereby preserving the underlying permanent tooth bud and for achieving the optimal cleaning and disinfection of the root canal.<sup>8</sup>

The established postulated norm regarding pulpectomy procedure is the root resorption which shouldn't exceed 1/3rd of its length.<sup>9</sup> In the present study, 60 canals from 34 extracted primary teeth that did not show root resorption more than 1/3rd of the root length were subjected for the evaluation of working length of radiographic method and EAL method and its accuracy was evaluated using CBCT. The study result revealed that there was a significant difference between the mean measurements of all three methods ( $p = 0.04$ ) when compared with each other.

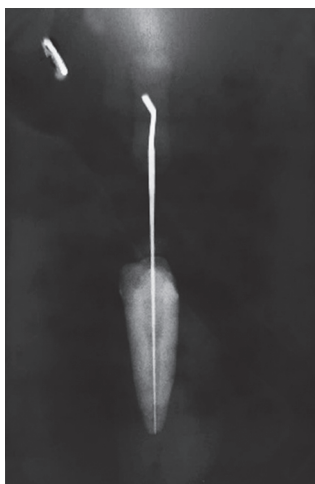


Fig. 1: Radiographic method of WL determination

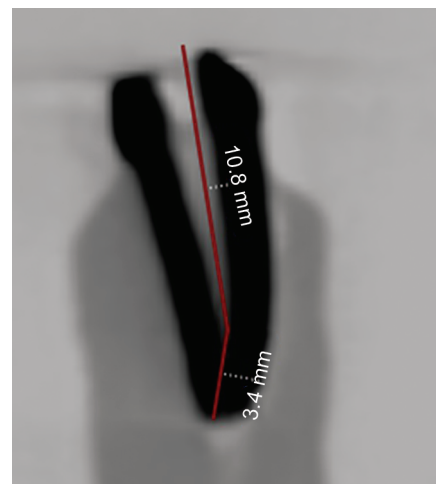


Fig. 2: Root length measurement by (Ez3Di software)

**Table 1:** Mean working length measurements by electronic apex locator (EAL) method, radiographic method, and cone-beam computed tomography (CBCT) method

Group	N	Mean (mm)	S.D	F value	p value
EAL	60	11.200	1.902		
Radiographic determination	60	11.708	1.552	3.291	0.04 <sup>a</sup>
CBCT	60	10.895	1.790		

<sup>a</sup>Statistically significant**Table 2:** Regression analysis between electronic apex locator (EAL) and cone-beam computed tomography (CBCT)

Model	Coefficients <sup>a</sup>							
	Unstandardized coefficients		Standardized coefficients		t	Sig.	95.0% confidence interval for B	
	B	Std. error	Beta	Lower bound			Upper bound	
1 (Constant)	1.108	0.520			2.130	0.037	0.067	2.149
EAL	0.874	0.046	0.929		19.086	0.000	0.782	0.966

<sup>a</sup>Dependent variable: CBCT**Table 3:** Regression analysis between Radiographic method and cone-beam computed tomography (CBCT)

Model	Coefficients <sup>a</sup>							
	Unstandardized coefficients		Standardized coefficients		t	Sig.	95.0% confidence interval for B	
	B	Std. error	Beta	Lower bound			Upper bound	
1 (Constant)	3.517	1.481			2.375	0.021	0.553	6.482
Radiographic	0.633	0.126	0.551		5.026	0.000	0.381	0.885

<sup>a</sup>Dependent variable: CBCT

Radiography is the most widely recognized, easily available and a good means of measuring the working length in a typical clinical setting. In pediatric patients, the number of radiographs and unnecessary radiation before and after the endodontic procedure is of prime concern. The child's cooperation is as essential to radiographic examinations as is the selection of the correct radiographic technique.<sup>10</sup>

In our study the paralleling technique of intra oral radiography was performed. In comparison of radiographic and EAL measurements in our study, it demonstrated that there was an insignificant difference ( $p = 0.34$ ) between the two methods. Hence it emphasizes the need to use EAL in estimating the working length in pediatric patients, rather than the use of radiographs. Similar studies<sup>2,9,11-13</sup> demonstrated insignificant difference between EAL and radiographic method. Even though radiographic methods demonstrated equal accuracy level in determining the root length, authors suggested practicing EAL to prevent the unnecessary ionizing radiation and discomfort during the placement of the film. Nellamakkada K et al., evaluated the acceptance level of EAL and radiographic methods and concluded that more number of negative behaviors were observed in radiographic methods assessed by Frankl's behavior rating scale and children were more receptive to EAL method of working length determination.<sup>14</sup> Most importantly radiographic technique provides 2D images of 3D structure, therefore small areas of resorptions are difficult to assess which may lead to over instrumentation and can cause damage to underlying permanent tooth.<sup>9</sup>

The limitations of radiographic methods were overcome by introduction of an electrical method, that is, EAL which can precisely locate the apical constriction of primary teeth. The accuracy level of an EAL can be influenced by a few factors: the apical foramen size, file type, file size, irrigating solution, and pulp electro-conductivity.<sup>15</sup> In our study we have used multiple frequency apex locator, which is a fifth generation type EAL (Woodpex III) that can efficiently function

even in the presence of exudate and blood. In addition to that EAL also has the advantage of measuring the root canal length in the resorbed roots.<sup>16</sup> Samples were immersed in alginate material to simulate the electrical resistance property of PDL which has been experimented in few studies<sup>16-20</sup> and found to be appropriate. Ngyungen et al., in 1996, reported that the file size did not affect the accuracy of EAL measurements.<sup>21</sup> The measurement was feasible and reproducible with inserted instruments in our study. In every root canal, the same file #15k file was used to provide comparable conditions for in vivo measurements. The k file was advanced till the display of 0.0 mark in apex locator with the lip hook inserted to the alginate material.<sup>8,19</sup>

Earlier, Berman LH et al. and Hulsman M et al. stated that when the apical foramen is large or immature the working length determination by EAL demonstrated less accurate results.<sup>22,23</sup> Later on, the efficacy of EAL was proven accurate in large apical foramen. The results of our study demonstrated insignificant difference ( $p = 1.0$ ) when EAL is compared with CBCT (actual length); this indicates the measuring accuracy of EAL was similar and comparable to the actual length using CBCT.<sup>19,24,25</sup> Various *in vivo* and *ex vivo* studies in the literature demonstrated insignificant difference between EAL and other actual length (AL) determination methods like direct visual method, direct visual method with magnification and stereomicroscope method.<sup>1,6-8,15,18,26-29</sup>

The reason for using CBCT values as actual root length is because, CBCT exhibited high accuracy in the working length determination and it produces undistorted images, which enhances the root length determination.<sup>30</sup> It also overcomes the drawbacks of conventional radiographs such as overlapping of images, 2D image presentation, and positioning errors. Even though it has many advantages, the effective dose of CBCT (5–300  $\mu$ Sv) is high when compared to IOPA (5  $\mu$ Sv) and is equal to a full mouth series of intraoral radiograph (35  $\mu$ Sv), but when compared to CT (1320–1400  $\mu$ Sv) the effective dose required is less. In addition to

tooth / root measurements and assessing the tooth morphology, Cone Beam Computed Tomography have also been used to assess the working length of primary and permanent roots. In our study CBCT and Radiograph demonstrated significant differences ( $p = 0.03$ ) which was contradictory to Morais AL et al. study.

The regression analysis demonstrated 63% accuracy by radiographic technique and 87% accuracy by EAL method to the CBCT measurements which is similar to the Krishna IS et al., whose results demonstrated 92% accuracy for EAL and 72% for radiographic technique.

Using Pearson correlation evaluation in our study, the tested EAL (Woodpex III) proved to be beneficial and precise in the working length determination with high correlation between EAL and actual length CBCT measurements. This result suggests that EAL is an effective tool in determination of working length in primary teeth which has advantages of unnecessary ionizing exposure of radiation to children (Gordon and Chandler- 2004) and added advantage of reduced discomfort to the children. Hence, EAL can be used as an alternative tool in determining the working length of primary teeth.

Furthermore, it is important to remember that this research was done in vitro, which may not include the errors that could exist in clinical settings when calculating the length of the root canal. There is scarcity of studies that have evaluated the working length accuracy of EAL and Conventional radiographic methods using CBCT measurements. Woodpex III (fifth generation) EAL has not yet been evaluated in the root canal length determination.

## CONCLUSION

From this study it is concluded that EAL is more accurate than the conventional radiographic technique in measuring WL in primary teeth. Also it reduces the unnecessary exposure to radiation, thereby facilitating child cooperation during treatment.

## REFERENCES

- Kumar LV, Sreelakshmi N, Reddy ER, et al. Clinical evaluation of conventional radiography, radiovisiography, and an electronic apex locator in determining the working length in primary teeth. *Pediatr Dent* 2016;38(1):37–41. PMID: 26892213.
- Oznurhan F, Ünal M, Kapdan A, et al. Clinical evaluation of apex locator and radiography in primary teeth. *Int J Paediatr Dent* 2015;25(3):199–203. DOI: 10.1111/ipd.12128
- Raghu KN, Daniel JG, Razvi S, et al. In vivo evaluation of the accuracy of working length determination using an electronic apex locator IPEX (NSK) on vital uninfected teeth and teeth with radiographic evidence of periapical lesions. *J Int Soc Prev Community Dent* 2014;4(6): S204–S208. DOI: 10.4103/2231-0762.149042
- Wankhade AD, Kumar R, Singh RK, et al. Root canal length determination by different methods in primary teeth: an in vivo study. *Pediatr Dent* 2013;35(2):E38–E42. PMID: 23635968.
- Dandempally A, Muppa R, Duddu MK, et al. Formulating a regression equation for determination of working length in primary molars using apex locators: a clinical study. *Eur Arch Paediatr Dent* 2013;14(6):369–374. DOI: 10.1007/s40368-013-0011-1
- Mello-Moura AC, Moura-Netto C, Araki AT, et al. Ex vivo performance of five methods for root canal length determination in primary anterior teeth. *Int Endod J* 2010;43(2):142–147. DOI: 10.1111/j.1365-2591.2009.01667.x
- Leonardo MR, Silva LA, Nelson-Filho P, et al. Ex vivo accuracy of an apex locator using digital signal processing in primary teeth. *Pediatr Dent* 2009;31(4):320–322. DOI: 10.1111/j.1365-2591.2007.01366.x
- Beltrame AP, Triches TC, Sartori N, et al. Electronic determination of root canal working length in primary molar teeth: an in vivo and ex vivo study. *Int Endod J* 2011;44(5):402–406. DOI: 10.1111/j.1365-2591.2010.01839.x
- Senthil D, Eagappan AS, Sathiyajeeva J, et al. Comparison of the accuracy of Propex II electronic apex locator and conventional radiography for working length determination in primary anterior teeth. *J Int Oral Health* 2016;8(6):729–732. DOI: 10.20477/jioh080617
- Dean JA, Avery DR, McDonald RE. *Radiographic techniques*. In McDonald and Avery's Dentistry for the child and Adolescent. 9th ed. India: Elsevier Mosby. 2011:47–63.
- Pinheiro SL, Bincelli IN, Faria T, et al. Comparison between electronic and radiographic method for the determination of root canal length in primary teeth RSBO RevistaSul-Brasileira de Odontologia 2012;9(1):11–16. ISSN: 1984-5685.
- Chougule RB, Padmanabhan MY, Mandal MS. A comparative evaluation of root canal length measurement techniques in primary teeth. *Pediatr Dent* 2012;34(3):e53–e56. PMID: 22795146.
- Bhat KV, Shetty P, Anandakrishna L. A comparative evaluation of accuracy of new-generation electronic apex locator with conventional radiography to determine working length in primary teeth: an in vivo study. *Int J Clin Pediatr Dent* 2017;10(1):34–36. DOI: 10.5005/jp-journals-10005-1403
- Nellamakkada K, Patil SS, Kakanur M, et al. A clinical evaluation of two electronic apex locators and conventional radiography in working length determination in primary molar and its influence on children's behavioral responses. *J Indian Soc Pedod and Prev Dent* 2020;38(2):158–163. DOI: 10.4103/JISPPD.JISPPD\_28\_20
- Odabaş ME, Bodur H, Tulunoğlu O, et al. Accuracy of an electronic apex locator: a clinical evaluation in primary molars with and without resorption. *J Clin Pediatr Dent* 2011;35(3):255–258. DOI: 10.17796/jcpd.35.3.7w71656740286960
- Angwaravong O, Panitvisai P. Accuracy of an electronic apex locator in primary teeth with root resorption *Int Endod J* 2009;42(2):115–121. DOI: 10.1111/j.1365-2591.2008.01476.x
- Krishnan IS, Sreedharan S. A comparative evaluation of electronic and radiographic determination of root canal length in primary teeth: an in vitro study. *Contemp Clin Dent* 2012;3(4):416–420. DOI: 10.4103/0976-237X.107430
- Tosun G, Erdemir A, Eldeniz AU, et al. Accuracy of two electronic apex locators in primary teeth with and without apical resorption: a laboratory study *Int Endod J* 2008;41(5):436–441. DOI: 10.1111/j.1365-2591.2008.01389.x
- Kayabasi M, Oznurhan F. Evaluation of the accuracy of electronic apex locators, cone-beam computed tomography, and radiovisiography in primary teeth: an in vitro study *Micros Res Tech* 2020;83(11):1330–1335. DOI: 10.1002/jemt.23524
- Tinaz AC, Alacam T, Topuz O. A simple model to demonstrate the electronic apex locator. *Int Endod J* 2002;35(11):940–945. DOI: 10.1046/j.1365-2591.2002.00576.x
- Nguyen HQ, Kaufman AY, Komorowski RC, et al. Electronic length measurement using small and large files in enlarged canals. *Int Endod J* 1996;29(6):359–364. DOI: 10.1111/j.1365-2591.1996.tb01398.x
- Berman LH, Fleischman SB. Evaluation of the accuracy of the Neosono-D electronic apex locator *J Endod* 1984;10(4):164–167. DOI: 10.1016/S0099-2399(84)80121-1
- Hulsmann M, Pieper K. Use of an electronic apex locator in the treatment of teeth with incomplete root formation. *Dent Traumatol* 1989;5(5):238–241. DOI: 10.1111/j.1600-9657.1989.tb00368.x
- Janner SF, Jeger FB, Lussi A, et al. Precision of endodontic working length measurements: a pilot investigation comparing cone-beam computed tomography scanning with standard measurement techniques *J Endod* 2011;37(8):1046–1051. DOI: 10.1016/j.joen.2011.05.005
- de Morais AL, de Alencar AH, de Araújo Estrela CR, et al. Working length determination using cone-beam computed tomography, periapical radiography and electronic apex locator in teeth with apical periodontitis: a clinical study *Iran Endod J* 2016;11(3):164–168. DOI: 10.7508/iej.2016.03.003

26. Shanmugaraj M, Nivedha R, Mathan R, et al. Evaluation of working length determination methods: an in vivo/ex vivo study. *Indian J Dent Res* 2007;18(2):60–62. DOI: 10.4103/0970-9290.32421
27. Ghaemmaghani S, Eberle J, Duperon D. Evaluation of the Root ZX apex locator in primary teeth. *Pediatr Dent* 2008;30(6):496–498. PMID: 19186775.
28. Bahrololoomi Z, Soleymani AA, Modaresi J, et al. Accuracy of an electronic apex locator for working length determination in primary anterior teeth. *J Dent (Tehran)* 2015;12(4):243–248. PMID: 26622278.
29. Adriano LZ, Barasuol JC, Cardoso M, et al. In vitro comparison between apex locators, direct and radiographic techniques for determining the root canal length in primary teeth. *Eur Arch Paediatr Dent* 2019;20(5):403–408. DOI: 10.1007/s40368-018-00413-5
30. Ghule KD, Naik S. Comparing the accuracy of cone-beam computed tomography and electronic apex locator for root canal length determination in primary teeth. *J Indian Soc Pedod Prev Dent* 2019;37(2):157–161. DOI: 10.4103/1319-2442.261334