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Research Article

To Compare the Accuracy of Working Length Determination in Primary Teeth Using Conventional Radiography, Apex Locator and CBCT Scan Technique: An *In Vitro* Study

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Received: July 04, 2025; **Published:** July 26, 2025

Abstract

Accurate working length (WL) determination is critical for successful pulpectomy in primary teeth. This study compared the accuracy of conventional radiography (CR), electronic apex locator (EAL), and cone-beam computed tomography (CBCT) in determining WL in 45 extracted primary single-rooted teeth. CBCT served as the gold standard. Results revealed statistically significant differences in mean WL measurements: CR (12.88 ± 2.05 mm), EAL (12.24 ± 2.21 mm), and CBCT (11.28 ± 1.95 mm) ($p = 0.002$). CR overestimated WL compared to CBCT ($p = 0.001$), while EAL showed no significant deviation ($p = 0.077$). Regression analysis indicated 87% accuracy for CR and 82% for EAL relative to CBCT. EAL demonstrated comparable precision to CBCT, suggesting its reliability as a radiation-free alternative. CBCT provided the most precise measurements, highlighting its utility in complex pediatric cases. The findings advocate for EAL in routine practice and CBCT for anatomically challenging scenarios.

Keywords: *Working Length; Primary Teeth; Pulpectomy; Electronic Apex Locator; Cone-Beam Computed Tomography; Conventional Radiography*

Abbreviations

CBCT: Cone Beam Computed Tomography; EAL: Electronic Apex Locator; WL: Working Length; MPR: Multiplanar Reconstruction; LED: Light Emitting Diode

Introduction

Preserving primary teeth with compromised pulp presents a significant challenge in pediatric dentistry. Pulpectomy, a specialized endodontic procedure, is commonly performed to retain these teeth. However, the procedure's success largely depends on accurately determining the root canal working length. Errors in working length estimation, whether too short or too long, can lead to treatment failure, causing difficulties for both the dentist and the child [1].

Obtaining precise diagnostic radiographs in children is often complicated by their limited cooperation and the restricted access within their oral cavity. Additional factors such as periapical pathology, physiological or pathological root resorption, complex root canal anatomy, and the close proximity of developing permanent teeth further complicate the process [1].

Traditional methods of working length determination include observing moisture or blood at the tip of a paper point, using tactile sensation to detect the apical constriction, and referencing average tooth length. Ingle introduced the radiographic method for working length determination, which is still widely used today. However, it requires precise positioning using the paralleling technique, which increases appointment time and exposes patients to ionizing radiation [2].

The advent of digital radiography has improved image quality and reduced radiation exposure, making endodontic treatment more efficient. Despite these advancements, concerns about radiation exposure remain [1]. Electronic apex locators (EALs) were introduced as a radiation-free alternative, offering safe, accurate, and painless working length measurements by detecting the apical constriction. Studies have shown that EALs reduce radiation exposure, shorten procedures, and enhance patient comfort, making them a preferred tool in pediatric endodontics [3,4].

EALs function by measuring electrical resistance at the apical foramen, providing more accurate measurements than visual inspection. Over the years, improvements in apex locator technology have increased their precision and safety, reducing the risk of over-instrumentation and minimizing damage to surrounding tissues [1]. Another advanced method for determining working length is cone-beam computed tomography (CBCT). CBCT offers high accuracy by providing three-dimensional imaging of root canal morphology and its variations. Compared to conventional radiography, CBCT eliminates image overlap and positioning errors while using a relatively low radiation dose [5,6]. Its 3D imaging capabilities make it a reliable alternative to traditional 2D radiographs, especially for pediatric patients [7].

Aim of the Study

This study aims to compare the accuracy of working length determination in primary teeth using conventional radiography, electronic apex locators, and CBCT techniques.

Objectives of the Study

- To evaluate the working length determination in extracted primary single rooted teeth using conventional radiography, apex locator and cone bean computed tomography (CBCT) scan.
- To compare the accuracy of conventional radiograph, apex locator with CBCT scan method in determining the working length of primary single rooted teeth.

Materials and Methods

The study was conducted at the Department of Pediatric and Preventive Dentistry, Rishiraj College of Dental Sciences and Research Centre, Bhopal, M.P., with approval from the institutional ethical committee. Forty-five extracted primary single-rooted teeth were collected, cleaned with 3% sodium hypochlorite, and stored in deionized water until further use.

Inclusion criteria:

- Extracted teeth with no physiological or pathological root resorption exceeding one third of total root length.
- No previous treatment done.

Exclusion criteria:

- Tooth with less than two third of actual root length.
- Tooth with more than one third root resorption.
- Tooth with anomaly.
- Tooth with calcification.

Each tooth was mounted on a wax block, numbered, and cleaned. An access cavity was prepared with a No. 4 round bur, the pulp chamber was deroofed, and the pulp was removed. The tooth and root canal were irrigated with sodium hypochlorite.

For conventional radiography, the tooth was positioned parallel to the X-ray film, and radiographs were taken using the paralleling technique. The file's position was checked, and if necessary, repositioned with a second radiograph.

For the apex locator, the teeth were immersed in alginate to simulate the periodontal ligament (PDL). A size 15K (ISO) file was used with the apex locator device, and readings were recorded when the device emitted a constant beeping sound and the LED flashed (Figure 1).

Figure 1: *Working length determination using electronic apex locator.*

For CBCT, the teeth were mounted on a U-shaped wax block and scanned using the CBCT machine. High-resolution images were captured, and working length was measured using the reconstructed 3D images and multiplanar reconstruction (MPR) (Figure 2 and 3).

Figure 2: *U shaped wax block to accommodate in the scanning tray of CBCT machine.*

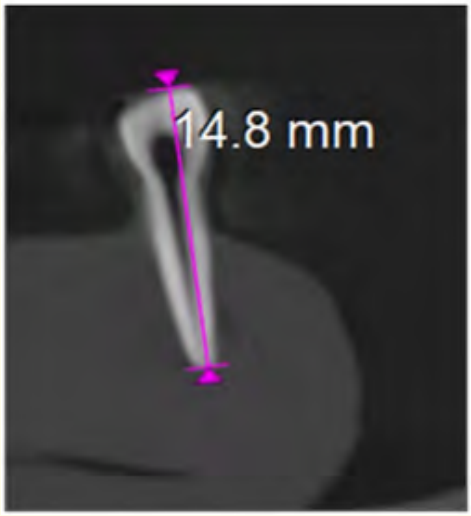

Figure 3: *Working length determination using CBCT scan technique.*

Results and Discussion

45 extracted primary single-rooted teeth were used in this investigation, and each sample's working length was assessed using a Cone Bean Computed Tomography (CBCT) scan, Apex locator, and conventional radiography. Based on the conventional radiograph, the mean working length was 12.88 ± 2.05 mm, with a minimum working length of 9.0 mm and a maximum working length of 17.0 mm. The average working length with an apex was 12.24 ± 2.21 mm, with a minimum of 8.0 mm and a maximum of 17.0 mm. In contrast, the average working length with CBCT was 11.28 ± 1.95 mm, with a minimum of 1.95 mm and a maximum of 16.0 mm. Conventional radiography had

the longest mean working length, whereas CBCT had the shortest. When the relationship between mean working length estimation by three approaches was compared using a one-way ANOVA test the three approaches' mean working lengths differ statistically significantly, as indicated by the F-value (6.769) and p-value (0.002*) (Table 1 and figure 4).

Methods	n	Mean working length (mm)	SD	Minimum (mm)	Maximum (mm)	F-value	P value
Conventional Radiograph	45	12.88	2.05	9.00	17.00	6.769	0.002*
Apex locator	45	12.24	2.21	8.00	17.00		
CBCT	45	11.28	1.95	8.00	16.00		

Table 1: *Comparison of mean working length measurement among three methods.*

**Statistically significant.*

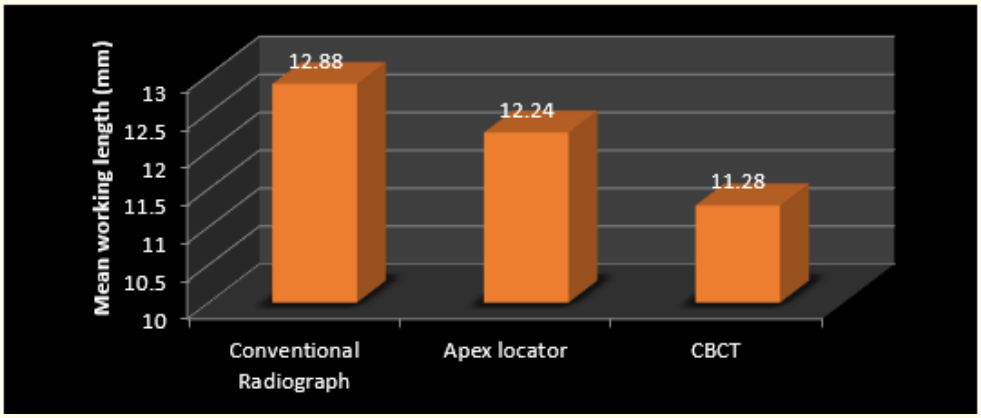

Figure 4: *Comparison of mean working length measurement among three methods.*

The mean difference between the apex locator and a conventional radiograph, when compared across groups, was 0.644; however, this difference was not statistically significant (p-0.308). CBCT and conventional radiography had a mean difference of 1.602, which was statistically significant (p-0.001). Apex locator and CBCT had a mean difference of 0.957, which was not statistically significant (p-0.077). When compared to CBCT, conventional radiography regularly produces longer working lengths, which could have clinical ramifications for operations requiring exact measurements. Similar performance in terms of mean working length is suggested by the fact that Apex Locator and the other two methods do not significantly differ from one another (Table 2 and figure 5).

The accuracy of the conventional radiography approach and the apex locator was assessed using regression analysis. While the radiographic method showed 87% accuracy in predicting the CBCT technique, AL showed around 82% accuracy of CBCT values.

Methods	Mean difference	95% Confidence Interval		p-value
		Lower Bound	Upper Bound	
Conventional radiograph vs apex locator	0.644	-0.394	1.683	0.308
Conventional radiograph vs CBCT	1.602	0.563	2.641	0.001*
Apex locator vs CBCT	0.957	-0.081	1.996	0.077

Table 2: *Intergroup comparison of working length measurement.*

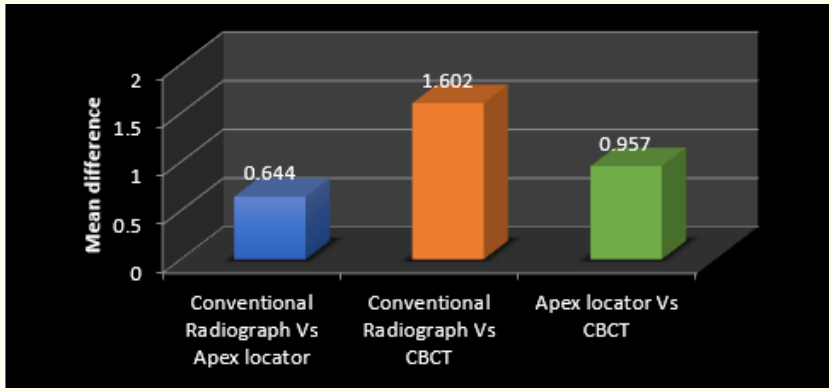

Figure 5: *Intergroup comparison of working length measurement.*

Discussion

Pediatric endodontics treats primary and young permanent teeth to maintain oral health [8]. Pulpectomy involves removing pulp, making accurate working length (WL) determination crucial. Precise WL measurement ensures proper obturation, prevents over-instrumentation, and protects the permanent tooth bud [1,9].

WL determination in primary teeth is challenging due to root resorption and shape variability [2]. Radiography is widely used but raises concerns about radiation exposure in children [2,10]. Child cooperation and proper technique are crucial. In this study, the paralleling technique was used.

The electronic apex locator (EAL) is a reliable alternative to radiography for WL determination, accurately identifying the apical constriction. Its accuracy depends on factors like apical foramen size and irrigants [11]. EAL is also useful for measuring WL in resorbed roots. In this study, alginate was used to simulate PDL resistance [12-15].

CBCT provides highly accurate, 3D WL measurements, overcoming radiographic limitations like image overlap and positioning errors [16]. However, its higher radiation dose requires cautious use in children. Connert., *et al*. (2014) found 0.2 mm voxel CBCT images effective for WL determination [17].

The present study compared the accuracy of working length determination using three methods: conventional radiography (12.88 ± 2.05 mm), apex locator, and CBCT (11.28 ± 1.95 mm). Significant differences were found, with radiography providing the longest measurements and CBCT the shortest.

The present study aligns with Shibin., *et al.* (2022), who reported significant differences in working length (WL) measurements among radiography, EAL, and CBCT. In their study, radiography showed the longest WL (11.708 mm), followed by EAL (11.200 mm), and CBCT (10.895 mm) [2]. This finding is consistent with ElAyouti, who observed that radiography tends to overestimate root canal length in 51% of cases [18]. Similar results were reported by Kaufman, Brunton, Mohammed, and Ehsan, who also noted the overestimation by conventional radiography [19-22]. Ghule., *et al*. (2022) found that CBCT provided the most accurate measurements, while apex locators showed slightly lower values [16]. Regression analysis in the present study revealed that radiography and apex locators predict CBCT-derived WL with 87% and 82% accuracy, respectively.

These findings are consistent with studies by Shanmugraj., *et al*, Mohammed and Mello-Moura., *et al*. who consistently reported apex locators as reliable tools for determining working lengths, with minimal differences from CBCT [23,24]. Furthermore, studies by Satishkumar Krishnan and Sheela Sreedharan highlighted apex locators high accuracy compared to radiographic methods [25]. Segato., *et al.* and similar studies demonstrated that EAL's accuracy is comparable to CBCT [26]. These results emphasize the superiority of CBCT in terms of precision, while apex locators offer a practical and reliable alternative with less radiation exposure. The importance of careful interpretation of radiographs to avoid overestimation is also highlighted in these studies.

Conclusion

Conventional radiography is widely used but has the least accuracy due to magnification errors, requiring careful interpretation. The electronic apex locator (EAL) offers good accuracy with no radiation exposure, making it reliable and practical, especially in pediatric dentistry. CBCT is the most accurate method with 3D imaging but has higher radiation and cost. CBCT is recommended for high-precision cases, while EAL is a reliable, radiation-free alternative, and conventional radiography remains useful with cautious interpretation.

Acknowledgements

First and foremost, I thank God for His blessings and guidance.

With heartfelt gratitude, I extend my deepest thanks to my guide and mentor, Dr. Arpana Bansal, for her invaluable guidance, patience, and encouragement throughout this journey. Her wisdom and support have been my greatest strength. To my beloved parents, Mrs. Kavita and Mr. Kailash, my dear uncle and aunt, Dr. Pravin Kherde and Mrs. Mayuri, and my sister Khushi-thank you for your endless love, sacrifices, and belief in me. I wouldn't be here without you. I am sincerely grateful to Dr. Prashant Prakash Jaju (OSD) for his timely advice and support, which helped shape this work. My appreciation also goes to all those who contributed, directly or indirectly, to the completion of this dissertation. Your kindness and assistance mean the world to me.

Conflict of Interest

None.

Bibliography

1. Sahni Anchal., *et al*. "A comparative evaluation of efficacy of electronic apex locator, digital radiography, and conventional radiographic method for root canal working length determination in primary teeth: An *in vitro* study". *International Journal of Clinical Pediatric Dentistry* 13.5 (2020): 523-528.

2. Shibin John., *et al*. "Evaluation of the working length determination accuracy by cone-beam computed tomography in primary teeth". *International Journal of Clinical Pediatric Dentistry* 15.1 (2022): S92-S96.

3. Agrawal Ishita., *et al*. "Comparative evaluation of the accuracy of electronic apex locator and digital radiography for working length determination in primary teeth: a systematic review". *Journal of Dentistry* 25.3 (2024): 203-214.

4. Ghaemmaghami Sara., *et al*. "Evaluation of the Root ZX apex locator in primary teeth". *Pediatric Dentistry* 30.6 (2008): 496-498.

5. Ozcan Gozde., *et al*. "Evaluation of root canal morphology of human primary molars by using CBCT and comprehensive review of the literature". *Acta Odontologica Scandinavica* 74.4 (2016): 250-258.

6. Gaurav Vivek., *et al*. "A study of root canal morphology of human primary incisors and molars using cone beam computerized tomography: An *in vitro* study". *Journal of Indian Society of Pedodontics and Preventive Dentistry* 31.4 (2013): 254-259.

7. Mehta Vivek and Nafis Ahmad. "Cone beamed computed tomography in pediatric dentistry: Concepts revisited". *Journal of Oral Biology and Craniofacial Research* 10.2 (2020): 210-211.

8. Neena IE., *et al*. "Comparison of digital radiography and apex locator with the conventional method in root length determination of primary teeth". *Journal of Indian Society of Pedodontics and Preventive Dentistry* 29.4 (2011): 300-304.

9. "Guideline on pulp therapy for primary and immature permanent teeth". *Pediatric Dentistry* 38.6 (2016): 280-288.

10. Parks Edwin T and Johan K Aps. "Radiographic techniques". McDonald and Avery's Dentistry for the Child and Adolescent. 10th edition. St. Louis: Elsevier (2015): 17-38.

11. Angwaravong O and P Panitvisai. "Accuracy of an electronic apex locator in primary teeth with root resorption". *International Endodontic Journal* 42.2 (2009): 115-121.

12. Tosun G., *et al*. "Accuracy of two electronic apex locators in primary teeth with and without apical resorption: a laboratory study". *International Endodontic Journal* 41.5 (2008): 436-441.

13. Krishnan Iyer Satishkumar and Sheela Sreedharan. "A comparative evaluation of electronic and radiographic determination of root canal length in primary teeth: An *in vitro* study". *Contemporary Clinical Dentistry* 3.4 (2012): 416-420.

14. Kayabasi Mevlut and Fatih Oznurhan. "Evaluation of the accuracy of electronic apex locators, cone-beam computed tomography, and radiovisiography in primary teeth: An *in vitro* study". *Microscopy Research and Technique* 83.11 (2020): 1330-1335.

15. Tinaz AC., *et al*. "A simple model to demonstrate the electronic apex locator". *International Endodontic Journal* 35.11 (2002): 940-945.

16. Ghule Kiran Dattatray and Shilpa Naik. "Comparing the accuracy of cone-beam computed tomography and electronic apex locator for root canal length determination in primary teeth". *Journal of Indian Society of Pedodontics and Preventive Dentistry* 37.2 (2019): 157-161.

17. Connert T., *et al*. "Accuracy of endodontic working length determination using cone beam computed tomography". *International Endodontic Journal* 47.7 (2014): 698-703.

18. ElAyouti Ashraf., *et al*. "The ability of root ZX apex locator to reduce the frequency of overestimated radiographic working length". *Journal of Endodontics* 28.2 (2002): 116-119.

19. Kaufman AY., *et al*. "Accuracy of a new apex locator: an *in vitro* study". *International Endodontic Journal* 35.2 (2002): 186-192.

20. Brunton Paul A., *et al*. "The effect of an apex locator on exposure to radiation during endodontic therapy". *Journal of Endodontics* 28.7 (2002): 524-526.

21. Ehsan Saroosh. "Comparative role of radiographs and electronic apex locator in working length determination". *Pakistan Oral and Dental Journal* 31.1 (2011).

22. Mohammed Aghareed. "An *in vitro* comparison of root canal length measurements in primary teeth". *Al-Rafidain Dental Journal* 9.1 (2009): 77-82.

23. Shanmugaraj Muthu., *et al*. "Evaluation of working length determination methods: An *in vivo/ex vivo* study". *Indian Journal of Dental Research* 18.2 (2007): 60-62.

24. Mello-Moura Anna Carolina Volpi., *et al*. "*Ex vivo* performance of five methods for root canal length determination in primary anterior teeth". *International Endodontic Journal* 43.2 (2010): 142-147.

25. Krishnan Iyer Satishkumar and Sheela Sreedharan. "A comparative evaluation of electronic and radiographic determination of root canal length in primary teeth: An *in vitro* study". *Contemporary Clinical Dentistry* 3.4 (2012): 416-420.

26. Segato André Vinícius Kaled., *et al*. "The accuracy of a new cone-beam computed tomographic software in the preoperative working length determination *ex vivo*". *Journal of Endodontics* 44.6 (2018): 1024-1029.

Volume 24 Issue 8 August 2025