



# Comparison of Radiovisiography, an Apex Locator and an Integrated Endomotor-inbuilt Apex Locator in Primary Teeth Endometrics

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## ABSTRACT

**Aim and objective:** To compare the accuracy of radiovisiography (RVG), Root ZX mini Apex locator, and Endo radar's inbuilt Apex Locator during working length determination in primary teeth with the actual/direct canal length.

**Materials and methods:** 58 primary teeth indicated for extraction in children of age group 4–12 years were selected. RVG, Root ZX mini Apex Locator, and Endo radar's Apex Locator were used to determine the working length intraorally. Following extraction of the teeth, the actual working length was determined with magnifying loupes (2.5×) using a K-file and an endodontic ruler. The data was tabulated and statistically analyzed.

**Results:** 84 canals (58 teeth) were evaluated and Root ZX mini Electronic Apex Locator (EAL) showed no statistically significant difference with the actual measurement ( $p = 0.18$ ) whereas Endo radar and RVG showed statistically significant difference. Endo radar underestimated, while RVG overestimated the working length. The most accurate method for working length measurements of the root canals in primary teeth was Root ZX mini EAL, followed by Endo radar and the least accurate was RVG.

**Conclusion:** The Root ZX mini Apex Locator showed the most promising results and had an excellent degree of agreement with actual working length, followed by Endo radar and RVG.

**Keywords:** Apex locators, Digital radiography, Integrated endomotor, Pediatric endodontics, Primary teeth, Root canal working length, Root ZX mini, Working Length Determination.

*International Journal of Clinical Pediatric Dentistry* (2022); 10.5005/jp-journals-10005-2123

## INTRODUCTION

Pulpectomy is the fundamental treatment of choice in deciduous teeth with irreversibly inflamed or necrotic pulp due to caries or trauma.<sup>1</sup> In contrast to the permanent teeth, estimation of exact root canal length in primary teeth is difficult, as physiologic resorption starts soon after the completion of root formation. The apical foramen shifts coronally during resorption and since, apical foramen cannot be detected or localized radiographically, an arbitrary working length, 2–3 mm short of radiographic apex, is preferred in resorbing deciduous teeth. Thus, the major shortcoming of a radiograph is that it does not actually determine the apical foramen and hence the correct actual working length.<sup>2</sup> Other disadvantages include radiation exposure and difficulty to take radiographs in children because of rigidity and thickness of the sensor, poor cooperation, gagging, and limited access.

The advent of apex locators brought a revolutionary advancement in the field of endodontics. The Root ZX (J Morita Corp., Tokyo, Japan), a third-generation Electronic Apex Locator (EAL), operates on the principles of dual frequency.<sup>3</sup> It has a compact size and a portable design; it also offers three programmable memory settings, shock resistance, and automatic calibration. However, there is a paucity of evidence on the in vivo/in vitro accuracy of Root ZX mini apex locator in primary teeth.<sup>4</sup>

Endodontic motors with integrated EALs were developed with the purpose of swift and easy root canal preparation. Apart from torque and speed control, these hybrid devices also ensure the monitoring of apical limit throughout the mechanical preparation of the canals.<sup>5</sup> Woodpecker's Endo radar

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**How to cite this article:** Khan SA, Khanna R, Navit S, et al. Comparison of Radiovisiography, an Apex Locator and an Integrated Endomotor-inbuilt Apex Locator in Primary Teeth Endometrics. *Int J Clin Pediatr Dent*. 2022;15(S-1):S18–S21.

**Source of support:** Nil

**Conflict of interest:** None

endomotor comes with a built-in apex locator. To the best of our knowledge, no study till date has evaluated the precision of the integrated Electronic Apex Locator intraorally in primary teeth. Few others studies have been performed in in-vitro models of permanent teeth.<sup>5–7</sup>

In the light of the above-mentioned facts, the purpose of this study was to determine working length in primary teeth intraorally (in vivo) by Radiovisiography (RVG), Root ZX mini Apex locator (J Morita Corp., Tokyo, Japan), and Endo radar's Apex (Woodpecker, Guilin.) and to compare with the actual/direct canal length after the extraction (*ex-vivo*).

## MATERIAS AND METHODS

After obtaining due approval from the Institutional Research and Ethics Committee, a cross-sectional study was performed on a selected group of children from Out-Patient Department of Pediatric and Preventive Dentistry. 84 root canals (58 teeth) of patients who fulfilled the following criteria were selected: children of age group of 4–12 years; primary teeth with not more than half of the root resorption; and primary teeth indicated for extraction because of nonrestorable crown, retained deciduous tooth, or other orthodontic reasons.

Children with the following were excluded: children with special healthcare needs; primary teeth indicated for pulpotomy or pulpectomy; primary teeth with more than half root resorption; and primary teeth that were fractured during extraction. The selection criteria were confirmed from the initial diagnostic radiograph and an informed consent was taken from the parents/guardian /guardian.

### Clinical Tooth Selection and Preparation

An endodontic access cavity was prepared after administration of local anesthesia. Extirpation of pulp tissue was done with fine barbed broach (Dentsply Maillefer, Ballaigues, Switzerland), and the canals were thoroughly irrigated and dried with paper points. Isolation was done with cotton roles and high evacuation system since the rubber dam placement was difficult or impossible in many grossly decayed teeth or the one in which the coronal structure was lost.

### Determination of Electronic Working Length

The electronic working length (EWL) was clinically determined using the third-generation Root ZX mini Apex Locator (J Morita Corp, Tokyo, Japan) according to the manufacturer's protocol. Files were positioned into the canals and advanced apically until the apex locator signal flashed at the 0.5 mm mark from the apex with an audible signaling sound. This procedure was repeated thrice, and the mean of these measurements was considered as the EWL. Reference points were marked with a felt tip marker on each tooth to facilitate working length measured from the same coronal reference during EWL measurement, radiographic WL measurement, and actual WL measurement.

Similarly, three repeated measurements of each canal to be studied were made using the Endo radars' Apex Locator (Woodpecker, Guilin) until the set signal flashed at 0.5-mm mark from the apex and the readings were noted.

### Determination of Radiographic Working Length

A tentative working length from fixed coronal reference point to the root apex was measured from the diagnostic radiograph and EWL. A #15 K-file (Dentsply Maillefer, Ballaigues, Switzerland) with a silicone stopper was inserted into the root canal and RVG was taken to confirm the tooth length, i.e., from coronal reference point to radiographic apex. Radiographic Working Length was obtained after subtracting 0.5 mm from the radiographic apex.

### Determination of Actual Working Length

The extraction of the selected tooth was performed immediately after electronic and radiographic working length determination with additional local anesthesia, if required. The actual tooth length of each canal in the extracted tooth was measured (i.e., from the reference point to the apical exit of the file at the apical foramen or resorption bevel of the root) using Dental Loupes with 2.5× magnification, K-file, and standard endodontic ruler. 0.5 mm was subtracted from this measurement and was recorded as the actual working length (AWL).

As per the study's protocol, only one investigator recorded all the readings. The investigator was trained and calibrated for all four methods. The statistical analysis was done using Statistical Package for Social Sciences Version 21.0 statistical Analysis Software. The values were represented in Number, Percentage (%), and Mean  $\pm$  SD.

## RESULTS

The working length measurements obtained using Root ZX mini, Endo radar Apex Locator, and RVG were compared with the AWL. The paired "t" test comparison of difference from the actual canal length indicated no statistically significant difference in Root ZX mini ( $> 0.05$ ); whereas, Endo radar and RVG showed highly statistical difference ( $< 0.001$ ). As compared to actual working length, digital radiography showed mean overestimation of working length by  $0.88 \pm 0.79$  mm; whereas, Endo radar Electronic apex locator (EAL) showed mean underestimation by  $0.36 \pm 0.46$  mm but Root ZX mini Electronic apex locator (EAL) showed a mean underestimation of only  $0.02 \pm 0.12$  mm (Table 1, Fig. 1)

Root ZX mini Electronic apex locator (EAL) showed no difference from AWL in 79 (94%), whereas Endo radar Electronic apex locator (EAL) showed no difference from AWL in 46 (54.8%) samples. RVG was least accurate and only 6 (7.1%) samples showed no difference from AWL. Friedman's test illustrated that there was a significant difference among three different techniques ( $p < 0.001$ ) in WL determination (Table 2).

## DISCUSSION

The precise establishment and maintenance of the apical limit are an important step for the successful outcome of root canal treatment, as it contributes to a safe and effective instrumentation.<sup>8,9</sup> The Root ZX Apex Locator has shown excellent performance since its introduction, which makes it the gold standard Electronic apex locator (EAL).<sup>10-12</sup> The production of the original Root ZX was discontinued by the J Morita Corporation. They then introduced Root ZX II and Root ZX mini based on the same working principle as of Root ZX. Aguiar et al.<sup>13</sup> evaluated the accuracy of Root ZX, Root ZX II, and Root ZX mini EALs and reported that all three devices were precise in measuring root canal working length without any statistical difference. Therefore, we used Root ZX mini by J Morita in our study to evaluate its precision in determining working length in primary teeth.

**Table 1:** Significance of difference in canal measurement using different techniques as compared to actual length (paired "t"-test)

S. N.	Method	Difference from actual length			"t"	"p"
		Mean (mm)	SD	% Difference		
1.	Digital radiography	0.88	0.79	6.7	10.27	<0.001
2.	Root ZX mini EAL	-0.02	0.12	-0.1	1.35	0.18
3.	Endo radar EAL	-0.36	0.46	-2.7	7.07	<0.001

Both Root ZX mini and Endo radar Electronic apex locator (EAL) used in our study belong to the third-generation EALs that work on the ratio method. Multiple frequencies are used by these devices to determine the distance from the end of the canal.<sup>14</sup> In the present study, three methods (RVG, Root ZX mini EAL, and Endo radar inbuilt EAL) were used for endodontic working length determination intra-orally in primary teeth. Following this, the ex vivo comparison with the actual working length was performed.

In the present study of working length determination by three different methods, Root ZX mini was found to be the most accurate in establishing true working length, as the WL measured by Root ZX mini was similar to the AWL without any statistically significant difference ( $p > 0.05$ ) (Table 11). In accordance to our study, Katz et al.<sup>15</sup> and Kielbassa et al.<sup>1</sup> reported that measurements obtained by Root ZX were identical to the actual length ( $p > 0.05$ ) whereas, Bodur et al.<sup>16</sup> found statistically significant difference between Root ZX measurements and actual canal length in vitro in primary teeth with and without resorption. This difference may be attributed to the fact that simulation of oral environment for working length determination is difficult outside the mouth in absence of periodontal ligament, which may affect the accuracy of the EALs.

In the current study, RVG revealed mean overestimation of 0.87 mm working length ( $p > 0.001$ ). This may be due to the fact that the physiological resorption of root in primary teeth occurs on the surface facing the developing permanent tooth, resulting in continuous alteration of the relative position of apical

foramen and consequently complicating the correct working length determination in the primary teeth. It is pertinent to note that radiograph helps in determining the root apex and not the apical foramen.

It was also observed that both the EALs (Root ZX mini and Endo radar) displayed a mean underestimation of the root canal WL, which was statistically significant for Endo radar while insignificant for Root ZX mini. Studies performed by Foud et al.<sup>17</sup> and Wu et al.<sup>18</sup> have implied that the accuracy of Electronic Root Canal Measurement is correlated with apical foramen size. Wide apical foramens with flared canal configuration have shown to demonstrate Electronic apex locator (EAL) measurements which are shorter than the actual length. (Table 1, Fig. 1).

In our study, RVG, Root ZX mini, and Endo radar coincided with the actual WL in 7.1%, 94% and 54.8% cases, respectively. Within an acceptable range of  $\pm 0.5$  mm, Root ZX mini Electronic apex locator (EAL) showed 100% accuracy followed by Endo radar (75%) and RVG (40.4%) (Table 2).<sup>19</sup>

This was in accordance with the studies performed by Labishetty et al.<sup>4</sup> and Angwarawong et al.<sup>20</sup> where Root ZX Electronic apex locator (EAL) in primary teeth demonstrated 95.1% and 96.7% accuracy and suggested that EALs as compared to digital or conventional radiographic method were more accurate in determining working length. Shahbhang et al.<sup>21</sup> also found that Root ZX with a clinical accuracy of 96.2% was able to locate the foramen in 25 permanent teeth. The result of our study was also comparable with the study performed by Aguiar et al.<sup>13</sup> where Root ZX mini demonstrated 100% precision considering  $\pm 1.0$  mm error from the root apex of the permanent. Whereas, difference in findings was reported in the studies conducted by Martinez-Lozano et al.<sup>8</sup> and Kqiku et al.<sup>9</sup> in which they compared radiograph and Electronic apex locator (EAL). Both the research articles inferred that no technique proved satisfactory to establish the actual working length and that EWL determination is not superior to the radiographic methods.

Ghule et al.,<sup>22</sup> mentioned that EALs cannot be considered as the most accurate method of working length determination when considering advanced radiographic techniques such as cone beam computed tomography (CBCT). However, the limitations of CBCT such as high cost, increased radiation exposure in children (5-38.3  $\mu$ Sv), low level of patient cooperation, feasibility, and difficult to access make it unrealistic to be used as a routine method for determining the working length during pulpectomies.

Our present study corroborates the excellent performance of Electronic apex locator (EAL) for working length determination in primary teeth. We also found that Endo radar with a built-in apex

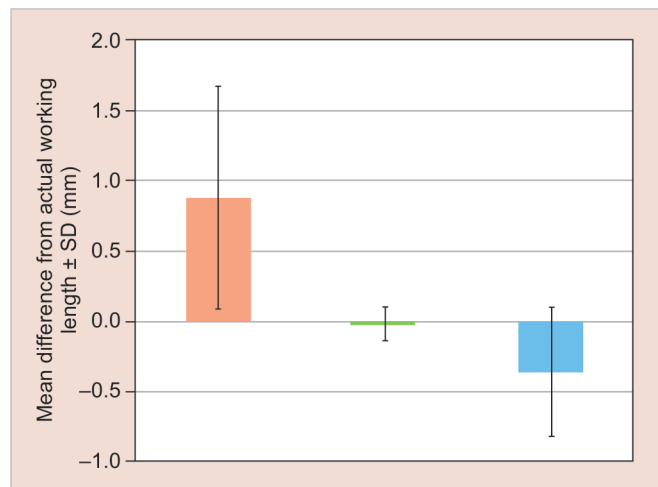


Fig. 1: Difference in canal measurement using different techniques as compared to actual length

Table 2: Range of difference from actual canal length using different techniques

S. No.	Difference from actual	Digital radiography		Root ZX mini EAL		Endo radar EAL	
		No.	%	No.	%	No.	%
1.	0-No difference	6	7.1	79	94	46	54.8
2.	$\pm 0.5$ mm	28	33.3	5	6	17	20.2
3.	$\pm 1.0$ mm	32	38.2	0	0	20	23.8
4.	$\pm 1.5$ mm	10	11.9	0	0	0	0
5.	$\pm 2$ mm or more	8	9.5	0	0	1	1.2

Significance of difference among different techniques (Friedman's test) (Non-parametric ANOVA)  $\chi^2 = 118.5; p < 0.001$

(EAL, electronic apex locator)

locator was more reliable than RVG. This device can be an asset to the pediatric endodontic practice because it eliminates the need for individual devices for determining working length and shaping of root canals therefore, resulting in decreased chairside time and increased child cooperation. It is also a cost-effective alternative.

In cases of marked resorption, the performance of both the Root ZX and Endo radar was deemed to be reliable means for performing the odontometry step during endodontic treatment of primary teeth, thus can be recommended. However, it should be emphasized that due to the large variation in root canal morphology, open apices, calcifications, perforation, and resorptions, using Electronic apex locator (EAL) alone without a preoperative radiograph are not recommended.

However, few limitations of our study were:

- The examiner was not blinded for recording the measurements. An improved design would have included more examiners to improve the reliability and validity of the study.
- The patient underwent an additional dental procedure and a radiographic exposure, which were not part of their treatment. However, to minimize the patient's exposure, the ALARA Principle (As Low as Reasonably Achievable) was followed.

In summary, Root ZX mini and Endo radar's Electronic apex locator (EAL) can be a valuable tool in determining working length in primary teeth. The inferences drawn can help the pediatric dentists to change the manner in which we perform pediatric endodontics while simultaneously reducing the radiation exposure along with the chair-side time while dealing with pediatric patients.

## CONCLUSION

Within the limitations of this study, we concluded that:

- Root ZX mini Electronic Apex Locator (EAL) is the best among the different test techniques for root canal working length measurement. It demonstrated an excellent degree of agreement with actual working length.
- In contrast to the earlier belief of Electronic Apex locators being not reliable for working length determination in primary teeth, our study demonstrated excellent reliability of Root ZX mini. Though Endo radar was not as good as Root ZX mini, still it proved to be superior to radiographic method of working length determination.

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