

Accuracy of an Electronic Apex Locator: A Clinical Evaluation in Primary Molars with and without Resorption

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Objective: The aim of this study was to evaluate the accuracy of electronic apex locator (Root ZX) in primary teeth with and without apical root resorption in vivo.

Study Design: The electronic working length was determined in 28 primary teeth (A total of 46 primary molar root canals with 24 roots without resorption and 22 roots with resorption) from twenty-eight healthy children using Root ZX. The teeth were then extracted. The actual length of each root was measured placing a K-File until the tip was visible at the apical foramen or the apical resorption level and approved with digital microscopic evaluation under 20× magnification and then withdrawn 1 mm. The distances from the file tip to the base of the rubber stop were measured and compared with the measurement obtained from apex locator. The data were evaluated with t test using standard statistical software (SPSS 13.0). The critical value of statistical significance was 5%. **Results:** For root canals without resorption, the accuracy of Root ZX was 79.16% and 95.82% within ± 0.5 and ± 1 mm, respectively. For root canals with resorption, the accuracy of Root ZX was 63.63% and 86.35% within ± 0.5 and ± 1 mm, respectively. No statistically significant differences were detected between the electronically determined lengths and the actual lengths regardless of whether or not resorption. **Conclusion:** Using a Root ZX Electronic Apex Locator in primary teeth with or without resorption is recommended for the determination of working length.

Keywords: primary teeth, resorption, working length determination, Root ZX, electronic apex locators
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INTRODUCTION

Accurate working length determination is an important part of successful root canal therapy. It is particularly important in primary teeth in order to minimize periapical injury and possible damage to the succedaneous teeth.¹ The endodontic anatomy of primary molars is difficult to predict because of the balance of resorption and hard tissue deposition.¹ Root resorption is a physiological process in the life span of primary teeth.^{2,3} Moreover, there is also pathological root resorption of primary teeth because of apical periodontitis. Shape, position, and dimension of the

root apex continuously altered. For this reason, resorption and hard tissue deposition make difficult to determine exact location of the apical foramen.

Traditionally, radiographs have been the principal tool for determining primary root canal lengths.⁴ Although it was reported that the location of the apical foramen could be accurately determined radiographically,⁵ the distance from the apical construction and apical foramen cannot be measured, when the apical foramen is located facially or orally. Moreover, since the image obtained from the radiograph is bi-dimensional and the tooth is three-dimensional, there are distortions and mistakes in evaluation of the working length measurements.^{5,6} It is also very difficult to get intraoral radiographs to measure the root canal length because of poor cooperation and limited access to the mouth of children.¹ Because of these reasons, radiography has important limitations to estimate the exact length of primary teeth.

Electronic apex locators have been developed to determine the working length of root canals. Suzuki & others⁷ first reported the use of an electronic apex locator in clinical endodontics. Determination of root canal length with new-generation electronic apex locators is well established in permanent teeth.⁸⁻¹¹ The accuracy of electronic root canal length measuring devices is influenced by moisture content in root canals and diameter of the apical foramen. The Root ZX (J. Morita Corp. Tokyo, Japan), electronic apex locator, could able to detect narrowest diameter of the root canal

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under both wet and dry conditions.^{12,13} It uses the impedance ratio instead of the impedance difference. This method simultaneously measures impedance values at two frequencies (8 and 0.4 kHz) and calculates a quotient of the impedances.¹⁴ The measurements appear to be less accurate when the apical foramen is immature or large.¹⁵⁻¹⁷ Many studies report the critical diameter of the foramen as 0.30 mm,¹⁶ or up to 0.62 mm.¹⁷ Consequently, the wide foramen of resorbed canals in primary teeth might affect the electrical measurement of root canal length.¹⁸

The accuracy of electronic apex locators in primary teeth has been evaluated *in vitro* in several studies,¹⁸⁻²³ but only one study evaluated *in vivo* accuracy of electronic apex locator in primary dentition.¹ Kielbassa *et al*¹ recommended using Root ZX in primary teeth that have undergone little or no resorption.

However, *in vivo* information regarding the accuracy of electronic root canal length measuring devices in primary teeth is limited. Therefore, the aim of this *in vivo* study was to evaluate the accuracy of an electronic apex locator in primary teeth with and without apical root resorption.

MATERIALS AND METHOD

Twenty-eight healthy children patients, ages 4 to 10 years old (mean age: 6.2) who were having primary molars extracted for orthodontic reasons or due to serious caries at Gazi University Faculty of Dentistry, participated in the study. The primary molars did not have metallic restorations or radiographically invisible canals. Informed consent was obtained from parents of children under a study protocol approved by the Ethical Committee of the University of Gazi, Faculty of Dentistry.

A preoperative periapical radiograph was taken. Sixteen primary molars responded normally to pulpal vitality testing (thermal and electric) and percussion. Pulp in 14 teeth were nonvital. After administration of local anesthesia Ultracaine D-S with 1:200,000 epinephrine, (Aventis, Istanbul, Turkey) the tooth was isolated with a rubber dam. An access cavity was prepared and the occlusal portion of the tooth was flattened to secure a consistent reference point. The excessive tissue in the chamber was removed and no attempt to remove the canal contents was made. The root canals were rinsed with 2% sodium hypochlorite. The apical foramen was located with the Root ZX (J. Morita Corp. Tokyo, Japan) via the advancement of an Endodontic #10 or #15 K-file (Dentsply Maillefer, Ballaigues, Switzerland) toward the apex. The file was advanced within the root canal to just beyond the foramen, as indicated by the flashing APEX bar, and the file was then withdrawn until the display read "1". The silicon stop was adjusted and the distance from the file tip to the base of the rubber stop was measured with a caliper to the nearest 0.01mm. The tooth was then extracted. Two primary molars were discarded due to damage that occurred during the extraction. The teeth were placed in 5.25% sodium hypochlorite for 4 hours in an effort to remove any soft tissue, and stored in 0.2% thymol solution.

After inspecting for roots for fractures and status of

periapex, primary molar teeth roots with more than 1/3 apical root resorption were discarded. A total of 46 primary molars root canals (24 roots without resorption and 22 roots with resorption) were evaluated. The actual lengths (ALs) were measured by inserting #10 or #15 K-file into the root canal until the file tip was just visible at either the apical foramen or the apical resorption level under a digital microscope (20x) (Leica 4000B, Leica Microsystems, Germany) and then it was withdrawn 1 mm. The distance from the file tip to the base of the rubber stop was measured. All measurements were performed by two operators with a caliper to the nearest 0.01 mm independently.

For each root canal, the difference was calculated by subtracting electronically determined lengths from the AL. Positive values indicated measurements exceeding the AL, negative values were short of the AL, and zero values indicated that the file tip was flush with minor constriction. The ALs ± 0.5 mm and ± 1 mm were used to evaluate the accuracy of Root ZX. The electronically determined lengths and ALs were compared using *t* test using standard statistical software (SPSS 13.0). Datas obtained from resorption and non-resorption canals within ± 0.5 mm and ± 1 mm were statistically analyzed using chi-square test. The critical value of statistical significance was 5%. For *in vitro* measurements, the inter-examiner reproducibility was calculated by Cohen's unweighted kappa statistic.

RESULTS

Results for measuring the actual lengths demonstrated excellent inter-examiner reliability ($\kappa = 0.98$).

The measurements obtained from the Root ZX are illustrated in Table 1. The mean and standard deviation (in mm) of the difference between the values obtained with the electronically determined lengths and the ALs in primary teeth root canals are presented in Table 2. No significant difference was observed between the resorbed and nonresorbed canals measured by Root ZX ($P=0.137$). (95% confidence interval of the difference; lower = -0.56728; upper = 0.8016). The chi-square test showed that there were no significant difference between the results of Root ZX in deter-

Table 1. Distribution of differences between the RootZX and actual lengths (acceptable range of ± 0.5 mm and ± 1 mm).

Distance from the actual length (mm) ^a	RootZX Root Canals			
	Nonresorption		Resorption	
	(n=24)	(%)	(n=22)	(%)
Less than -1.0	0	0	3	13.63
-0.5 to 1.0	2	8.33	3	13.63
-0.5 to 0.0	8	33.33	8	36.36
0.00 to 0.5	11	45.83	6	27.27
0.5 to 1.0	2	8.33	2	9.09
More than 1.0	1	4.16	0	0

^a Negative values indicate measurements short of the AL. There were no significant differences between the RootZX and actual length regardless of whether or not resorption ($P > 0.05$).

Table 2. Mean difference between the values obtained with electronic apex locator and the actual length (mm)

	Mean ^a	SD
Root ZX		
Nonresorption	0.24	0.36
Resorption	-0.28	0.42

^a Minus sign indicates measurements short of the actual lengths

mining of the resorbed and non-resorbed canals within ± 0.5 mm ($P=0.260$) and ± 1 mm ($P=0.097$).

For canals without resorption, the accuracy of Root ZX was 79.16% and 95.82% within ± 0.5 and ± 1 mm, respectively, and the mean Root ZX measurement was 0.24 mm from the AL with a standard deviation of 0.36 mm. For roots with resorption, the accuracy of Root ZX was 63.63% and 86.35% within ± 0.5 and ± 1 mm, respectively, and the mean Root ZX measurement was -0.28 mm from the AL with a standard deviation of 0.42 mm.

DISCUSSION

This presented study clinically compared the electronically determined length with AL in primary teeth with and without resorption. The results of this study are generally in agreement with previous reports on the accuracy of the Root ZX in primary teeth.^{1,19,20,22,23} In the current literature, only one paper compared electronic device measurements with actual root canal lengths of primary teeth *in vivo*.¹ Kielbassa and others¹ used the Root ZX for determining root canal length in primary teeth with and without resorption *in vivo*. They found no significant difference between resorbed and non-resorbed canals. They found the accuracy of Root ZX as 64% within ± 1 mm, which was lower than our findings (95.82% within ± 1 mm). Different from the study of Kielbassa *et al*, in our methodology, the Root ZX was used according to Leonardo's *et al*²¹ recommendation. The K-file was inserted into the root canal until the display read "1". They reported that using the "1" reading on the electronic apex locator's display presented the best correlation with the direct method of actual root canal length at 1 mm short of the root apex. This may explain difference between the results of two *in vivo* studies.

Factors that may influence the accuracy of electronic apex locators are the size of the apical foramen, type and size of the measuring file, irrigation solution and electro-conductivity of the pulp.^{16,17}

The electronic apex locator measurements in root canals with large apical size resulted in underestimation of the root canal length.²⁴ Although primary molars with root resorption show the same tendency in this study, electronic apex locator measurements in root canals with resorption were not considerably shorter than the actual lengths. The effect of root resorption has been investigated in *in vitro* studies. In primary teeth, it has been shown that the use of an electronic apex locator gave accurate measurements in the presence of root resorption.^{18,22,23} Different from the other *in vitro* studies, Bodur & others¹⁹ investigated the different types of

electronic apex locators in primary teeth with resorption; they found no significant differences between the Root ZX (Morita) and the Endex (Osada, Tokyo, Japan).

Ngyungen *et al*²⁵ reported that file size did not affect the accuracy of electronic apex locator measurements. In this study, the measurements were practicable and reproducible with inserted instruments. The same file size (#10 or #15 K-file) was used in every root canal to have comparable conditions for the *in vivo* measurements.

Meares and Steinman²⁶ reported that the accuracy of electronic apex locator is not influenced by different concentrations of sodium hypochlorite. In our study, the root canals were rinsed with 2% sodium hypochlorite.

In the presented study, 14 pulps were nonvital. It has been shown that pulpal vitality does not significantly affect of the accuracy of electronic apex locators.⁸ On the other hand, some authors suggested that in necrotic cases with inflammatory root resorption, the apical constriction might be altered, this would lead to a lower accuracy.^{27,8} In addition, Ghaemmaghami *et al*²⁸ reported that Root ZX accurately determined crown to apex length in the presence of gingival fistula or parulus in primary teeth.

Supporting to our results, Angwaravong and Panitvisai²³ suggested that although the apical foramen was resorped and enlarged, the conical shape of the canal was still maintained. The Root ZX can identify the narrowest canal diameter regardless of anatomical or mechanical constriction.²⁵ Regarding this notion, Angwaravong and Panitvisai²³ reported that the electronic apex locator was capable of functioning accurately in primary teeth with resorption because the root canal typically has a decreasing taper towards the defect.

The combinations of tactile sense and radiography have important limitations in estimating the exact length of primary teeth because of root resorption. The electronic apex locator may be useful in determining working length in primary teeth with resorption. Moreover, the use of electronic apex locator s during endodontic therapy might potentially decrease the radiation exposure to children by reducing the number of radiographs required for successful endodontic therapy.²⁹ However, electrical determination of root canal length should support with other diagnostic measures to increase the safety of endodontic treatment

In conclusion, the results of this study confirm that the Root ZX can accurately determine the root canal length in primary teeth with and without root resorption.

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