Original Article

Accuracy of an Electronic Apex Locator for Working Length Determination in Primary Anterior Teeth

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Abstract

Objectives: Correct determination of working length is an important step for success of endodontic therapy. Conventional radiography has limitations in providing the accurate location of apical foramen. For this reason, electronic apex locators (EALs) were developed to shorten the treatment time and decrease the radiation dose. The aim of this study was to evaluate the accuracy of Root ZX EAL for working length determination in primary anterior teeth.

Materials and Methods: In this in-vitro study, 50 extracted primary anterior teeth with root resorption were selected with no obstructed canals or history of previous root canal therapy. Working lengths were measured by direct observation of actual length (AL), radiography and Root ZX EAL. A variation of ±0.5 mm from the AL was considered acceptable. The results were analyzed statistically using paired t-test and interclass correlation coefficient (ICC) at 0.05 level of significance.

Results: Considering an acceptable 0.5 mm margin from AL (direct measurement), the accuracy of Root ZX EAL and radiography was found to be 86% and 76%, respectively. Absolute value of error from AL was significantly lower for ZX compared to radiography ($P<0.001$). Interclass correlation comparing both radiography and Root ZX with AL showed strong correlations.

Conclusion: Root ZX EAL can be used as a reliable tool for obtaining root canal length in primary anterior teeth with resorption.

Keywords: Tooth, Deciduous; Radiography; Tooth Apex

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INTRODUCTION

The main purpose of endodontic treatment is to preserve the teeth affected by dental caries, traumatic injuries or other causes and also their supporting tissues. In such cases, maintaining the vitality of the pulp tissue must be primarily attempted. However, a non-vital tooth is still able to function normally in the oral cavity [1]. In primary teeth, unlike the permanent teeth, it is not necessary to determine the exact length of the root canal, because of their open apices [2].

Root length determination is crucial for a successful treatment, because of the need for complete debridement and disinfection without traumatizing the periapical tissue [3].

Inaccurate working length determination may lead to over-instrumentation and overfilling. This error may traumatize the underlying permanent tooth structure [4]. Radiography is among the most common and widely used techniques for root canal length determination. However, it may be misleading particularly in cases with resorption and apical constriction. Furthermore, poor cooperation of children makes it difficult to take a radiograph with acceptable diagnostic value [2,5]. The development of EAL has enabled more accurate measurement of the root canal length. Several studies have reported the accuracy of these devices along with their specific measurement potentials, including but not limited to the accurate measurement in presence of electrolytes [6-10]. The Root ZX (J Morita Corp. Kyoto, Japan) is a third generation EAL that measures the root length by calculating the ratio of two different AC frequencies [11]. Root ZX is reportedly capable of detecting the narrowest diameter of the root canal under both wet and dry conditions [12]. Several factors can affect the electronic measurement of root canal length like the presence of root resorption, which occurs physiologically in primary teeth [5]. Although many studies have evaluated the accuracy of EALs in permanent teeth [6-9,13,14], information regarding the accuracy of these devices for primary dentition is limited [11,15-18]. The aim of this study was to evaluate the accuracy of an EAL (Root ZX) and conventional radiography for working length determination of the root canals of primary anterior teeth with apical resorption in comparison with direct measurement.

MATERIALS AND METHODS

In this in vitro study, 50 extracted human primary anterior teeth with visible root resorption were selected.

The teeth with more than one-third of the root length resorption were excluded from the study. There were no calcified canals or history of previous root canal therapy. All teeth were extracted for reasons unrelated to the study such as extensive caries. The teeth were immersed in 10% formalin. All teeth surfaces were then cleaned with scalers and curettes to remove organic debris and deposits. Then, the teeth were stored in normal saline. After cutting the crowns at the cementoenamel junction (CEJ), the coronal portions of the roots were flattened with a tapered diamond bur using a high-speed handpiece under water irrigation to obtain a smooth surface to serve as a stable reference for all measurements. The pulp tissue of the canals was removed using barbed broaches. The reference point was marked on the coronal portion of the roots with a fine paint marker to facilitate accurate reinsertion of the files. For direct measurement of root canal length, a K-file (Mani Inc., Tokyo, Japan) with a rubber stop was passively introduced into the root canal, (according to the diameter of the canal) until its tip was visible at the apical foramen or the apical resorption level and was then withdrawn by one millimeter. The correct position of the file tip was confirmed under a stereomicroscope (Bongshin 25303, Gyeonggi-do, South Korea) at ×10 magnification. The distance from the file tip to the base of the rubber stop was measured by an endodontic ruler with an accuracy of 0.5 mm. All working lengths were also measured radiographically. For this purpose, sticky waxes were used to fix the teeth on an E speed film (Kodak, Tokyo, Japan). The films were then placed parallel to the X ray tube (Trophy, Tokyo, Japan). After film development, canal length was measured using a transparent ruler (0.1 mm accuracy). To measure the working length electronically, the teeth were then embedded in agar – agar gel, (Qualigens Fine Chemicals Pvt. Ltd., Mumbai, India) (1% agar + 1 L of 0.9% normal saline) in a plastic container to act as a conductor gel simulating the periodontium.

A wax plate was fixed to the flat occlusal table to be used as the coronal reference. The canal was then irrigated with 0.9% normal saline solution. Excess normal saline solution was removed from the pulp chamber using a cotton pellet. The electronic measurement was made using the Root ZX apex locator (J. Morita Corp, Tokyo, Japan). The labial clip was inserted in agar – agar gel prior to its setting, and a #25 K-file (Mani Inc., Tokyo, Japan) attached to the file holder was gently inserted until the display read "apex". Then, the rubber stop was placed at the coronal reference, and the root canal length was measured electronically. The measurements (± 0.5 mm) were used to evaluate the accuracy of the two methods. Measurements shorter than the AL by more than 0.5 mm were classified as "shorter than AL", and measurements longer than AL by more than 0.5 mm were considered as "longer than AL".

Two readings were made for each method by the same operator and the mean value was recorded. Data were analyzed by paired t-test and the ICC. A P-value <0.05 was considered statistically significant. The measurements made by each method were compared with AL using the ICC.

RESULTS

The ICC values of Root ZX (0.92) and radiography (0.90) showed a high correlation between each group and AL. Considering 0.5 mm acceptable margin, the accuracy of Root ZX and radiography was found to be 86% and 76%, respectively (Table 1). The mean and standard deviation (SD) of the measurements are shown in Table 2.

DISCUSSION

The absolute value of error from AL was calculated for each method, which was lower for ZX than radiography and paired t-test showed a significant difference between these two values (P<0.001). Root canal length determination is among the most important factors for successful root canal treatment in both permanent and primary teeth. However, exact measurement of the root canal length of primary teeth is not obligatory. Conventional radiography is a common technique for working length determination. But, it has a number of shortcomings; its accuracy depends on the child's cooperation as well as the operator's proficiency. Furthermore radiography may not be able to show small degrees of resorption [2,5]. Radiographic image may also be ambiguous due to the superimposition of the surrounding anatomical structures. To surmount such disadvantages, EAL was introduced particularly for use in children. The new generations of these devices are based on electrical principles and are capable of determining the root canal length in presence of moisture and fluids. In the current study, the accuracy of Root ZX EAL was evaluated and the results were compared with the actual canal length and radiography.

This device is reported to be extremely useful in children with gag reflex who cannot tolerate radiography [19]. Apex locators are based on electrical principles rather than the biological characteristics of tissues. Therefore, in an in vitro study, the extracted teeth must be immersed in a medium with electrical resistance properties similar to those of the periodontium [20].

Table 1. The number and percentage of measurements that were within the acceptable range of ± 0.5mm

Method of measurement	Acceptable length n (%)	Shorter than AL* n (%)	Longer than AL n (%)
Root ZX	43 (86)	5 (10)	2 (4)
Radiography	38 (76)	4 (8)	8 (16)

* Actual Length

The agar – agar gel used in this study was found to be appropriate and the technique has been shown to be reliable in previous studies [21,22]. The apex locator used in this study was Root ZX. This device was developed by Kobayashi and Suda in 1990 [23]. ZX was useful and accurate for canal length determination in primary anterior teeth with root resorption.

There was an almost high correlation between the electronic and direct root canal length measurements [24]. The first study on the use of apex locator in primary teeth was in 1996 and reported that Root The effect of root resorption on the accuracy of EAL is not clear. Shabahang et al. demonstrated that Root ZX located the root end accurately even in cases with resorption [25].

In the current study, the accuracy of Root ZX in primary teeth with root resorption was 86%. This result is in accordance with that of Katz et al, [24] Tosun et al, [12] and Angwaravong and Panitvisai [4].

In a study by Tusan et al, the accuracy of Root ZX (±0.5) was 83% in resorbed primary teeth and 89% in teeth with no resorption. They found no significant difference between the resorbed and non-resorbed root canals measured by Root ZX ($P<0.05$) [12]. The accuracy of Root ZX in the current study was higher than that in a study by Kielbasa et al. They reported that Root ZX was accurate within one millimeter in 64% of primary teeth [2]. Goldberg et al, also reported that the accuracy of Root ZX was 62% with ±0.5 mm clinical tolerance when compared with direct measurements [26].

The difference between their results and those of the current study might be due to the differences in test conditions. In the current study, both Root ZX and radiography showed high correlations with AL. The mean difference between Root ZX and AL was significantly lower than the difference of radiography with AL ($P<0.001$); this shows that Root ZX measurements are closer to AL.

In a study by Katz et al, [24] the mean canal length according to radiography was higher than the AL, which is similar to our results. Thus, in pulpectomy of primary teeth, endodontic files must be adjusted one or two millimeters short of the radiographic apex determined by radiography to avoid over-instrumentation and injury to the permanent successors. On the other hand, radiographic evaluation is difficult in primary teeth with physiological resorption at the buccal or lingual aspects of the roots, resulting in an increased risk of over-instrumentation [5,12].

It should be noted that in the current study, the parallel technique was used, which is more accurate but difficult to perform intraorally. In vivo radiographs are of lower quality because of the surrounding bone and the potential of decreased clarity due to angulation errors [5].

The EAL method does not expose the patient to ionizing radiation.

Radiography, however, is still necessary to reveal root morphology, evaluate primary root resorption and investigate the tooth's position in relation to its permanent successor. Further in vivo studies of these methods in primary teeth are recommended.

CONCLUSION

The accuracy of Root ZX EAL was found to be high in the primary anterior teeth despite root resorption. Therefore, using this device as an adjunct is recommended for root canal length measurements in primary anterior teeth.

Table 2. Comparison of errors of each method from the actual root canal length reading

	Root ZX	**Radiography**
Mean ± SD (mm)	11.73±1.29	12.17±1.17
Actual canal length(mm)	11.80±1.14	11.80±1.14
Absolute values of errors	0.36±0.29	0.53±0.30
P value	**P<0.001**	

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