ORIGINAL ARTICLE

INFLUENCE OF PULP CONDITION ON THE ACCURACY OF ROOT ZX ELECTRONIC APEX LOCATOR

ZAIN Z HAFIZ

ABSTRACT

The objective of this study was comparison between digital radiography as the conventional method and Root ZX electronic apex locator (EAL) in measurement of root canal length in primary anterior teeth, and to clinically assess the influence of pulp status (vital or necrotic pulp) on the accuracy of Root ZX EAL. Thirty-five maxillary primary anterior teeth indicated for pulpectomy in 19 healthy pediatric dental patients were selected for the study. Electronic canal measurements were done using Root ZX electronic apex locator with file in place, and radiographs were taken to confirm the correct working length. Radiographic measurements were obtained by measuring the root canal length through digital ruler in Romexis software (Planmeca, 4.5.2.R). Root canals were cleaned, irrigated, dried, obturated and teeth restored. Considering that the clinically acceptable error tolerance of ±0.5 mm, 48.6% (17/35) canals showed acceptable differences between the two measurements. There was no significant (P>.05) effect of pulp condition on the measurement accuracy of Root ZX (EAL). Root ZX (EAL) could be used as an adjunct tool to radiographs during root canal therapy in primary anterior teeth.

Key Words: *Primary teeth, Pulp therapy, Root Apex Locator, Vital teeth, Necrotic teeth.*

INTRODUCTION

Pulp therapy in primary dentition deals with the treatment of pulpally involved primary and young permanent teeth in children. The main purpose of pulp therapy in primary dentition is to preserve the integrity and health of the oral tissues.[1] Pulpectomy is defined as a root canal treatment for the irreversibly or infected pulpal tissues that has resulted from caries or trauma.[2] Definitive rules for successful endodontic treatment has been established for the permanent dentition, unlike the primary dentition due to the open apices that make the process of determining the root canal length difficult.[3] Determination of the root canal length (working length, root length, tooth length) is a significant part in the endodontic treatment. Root canal length refers to the distance from the reference point determined on the crown of the tooth to the point at which canal preparation and filling ends.[4]

Ingle's method of using radiographs was one of the most known and reliable ways for determining the root canal length.[5] However, it is not easy to achieve accuracy because of the difficulty to locate the apical constriction, and factors such as angulations of the cone beam, exposure distorted image that lead to error because of the laterally located foramina and radiographic artifact that could occur and lead to misinterpretation. Furthermore, there is a radiation hazard to the patient and the dental staff.[5,6]

Electronic apex locator (EAL) was first introduced by Sunada (1962)[7] to locate the root apex for measuring the root canal length. Kielbassa et al (2003)[8] recommended the use of Root ZX apex locator for root canal length determination in primary teeth. Ghaemmaghami et al (2008)[9] reported that using Root ZX in primary incisors can accurately measure the length of the root canals. Angwaravong and Panitvisai (2009)[10] concluded that the accuracy of the Root ZX was high even in the presence of root resorption.

The accuracy of the EAL may be affected by the presence of blood within the root canal as an electrolyte material. There have been some studies in permanent dentition on the effect of the presence or absence of blood within the root canal on the accuracy of EAL, concluding that pulp condition (vital or non-vital) had no significant effect on the accuracy of various EALs.[11-15]

However, there are no studies reported the influence of pulp condition on the accuracy of EALs in primary teeth. Therefore, the objective of this study was to make comparison between digital radiography as the conventional method and Root ZX electronic apex locator EAL in measuring the root canal length in primary anterior teeth, and to clinically assess the

Zain Z. Hafiz, Lecturer, Department of Pediatric Dentistry and Orthodontics, College of Dentistry, King Saud University, Riyadh, Saudi Arabia. **Correspondence Address:** Dr Zain Z Hafiz, Department of Pediatric Dentistry and Orthodontics, College of Dentistry, PO Box 60169, Riyadh 11545, Saudi Arabia
Email: dr_zainh@yahoo.com Tel: +966 11-4694814

Received for Publication: February 21, 2018
Revised: March 6, 2018
Approved: March 9, 2018

influence of pulp status (vital or necrotic pulp) on the accuracy of Root ZX (EAL).

METHODOLOGY

Patient and Teeth Selection

This study was registered with College of Dentistry Research Center (CDRC), King Saud University. A written consent was obtained from the parents/guardians of every child selected for the study. The children were selected from those attending the pediatric dentistry clinics of the College of Dentistry, King Saud University, Riyadh.

Inclusion criteria: maxillary primary anterior single rooted teeth which included central incisors, lateral incisors and canines with irreversible pulpitis or necrosis indicated for pulpectomy, roots status with no or mild resorption. Exclusion Criteria: Teeth with previous endodontic treatment, calcification, metal restoration, non-restorable crowns, periapical radiolucency reaching to the permanent tooth bud, teeth related to cysts, pathologic resorption of more than one-third of the root, incomplete root formation and obvious internal resorption or teeth with difficulty to determine the root canal position. Also children with systemic illness such as cardiac, liver, blood diseases and immunocompromised children were excluded.

Electronic Measurement of the Root Canal Length

Preoperative radiographs were taken for each tooth. Patients were anesthetized using topical anesthesia followed by local anesthesia. Rubber dam was applied for isolation. Crowns of the teeth were prepared to obtain a definite and reproducible reference point. Access cavities were prepared using round bur in high-speed hand piece. Root ZX (Morita, Kyoto, Japan) was used for electronic canal length determination according to the manufacture's guidelines. The steps for electronic measurement included placing a clip in the patient's lip commissure. A K-File was chosen according to the size of each canal estimated from the preoperative radiograph of the tooth, then attached to the Root ZX (EAL). The file was then gently inserted into the root canal until flashing bar on the unit displayed, and an audible sound heard indicating that the proper canal length was reached. Deciding the proper working length was based on Ingle's technique (the file 1 mm shorter than the radiographic apex) (Ingle, 1957) and the clinically acceptable error tolerance is ±0.5 mm (Kim and Lee, 2004 and Wrbas et al 2007).[16,17] Then, a silicone stopper was placed at the prepared coronal reference, and a radiograph taken utilizing the paralleling technique, with Planmeca Prox intraoral x-ray unit to confirm the position of the file in the root canal. The root canal measurement using Root ZX (EAL) was performed three times and the average was recorded.

Radiographic Measurement of the Root Canal Length

Using the digital ruler of the Romexis soft wear (Planmeca, 4.5.2.R), initial working length of the root canal was estimated using Ingle's technique. The estimated root canal length was measured as the distance from the prepared reference point to the point (1 mm) shorter than the radiographic apex. K-file was then placed in the tooth according to the estimated length and x-ray was taken with Planmeca Prox intraoral x-ray unit using the paralleling method. The patient was seated and a protective lead apron with thyroid collar was placed over the patient's body with his/her head supported and the occlusal plane horizontal and parallel to the floor. The X-ray machine Planmeca Prox automatically was adjusted to 63kV and exposure time was 125 seconds.

After initial working length was determined, the coronal and radicular pulp tissues were removed using K-files and root canals were cleaned and irrigated with sodium hypochlorite (1%) and normal saline. Furthermore, using paper points, the canals were dried and obturated with a biocompatible material. The teeth received final restorations and a final x-ray was taken. The difference between electronic root canal length measurements and radiographic root canal length measurements were calculated based on the difference between the initial files lengths for each method used for the individual root canal by using standard endodontic ruler to measure the file length.

Statistical Analysis

The data were entered and analyzed using SPSS PC+ software (21.0). Descriptive statistics (mean, SD, and proportion) were derived. The Pearson chi-square test was used to determine any relationship between the length values of the two methods. A p-value of $< .05$ was considered as statistically significant. Intra-operator reliability of root canal measurements was determined earlier in a pilot study by using intra-class correlation coefficient (ICC).

RESULTS

Intra-operator reliability test was high (ICC= 0.92). Differences between the two measurement methods (EAL and radiography) of primary root canal length are shown in Table 1. Out of the 19 children who participated in this study, 9 were males and 10 females, age range 5 to 9 years and mean age of 6.8 (± 1.23) years. Thirty-five teeth met the inclusion criteria and were indicated for pulpectomy. About half of the cases (48.6%) showed acceptable differences between the two measurements. The Pearson chi-square test revealed no significant effect of the pulp condition on measurement accuracy ($p > .05$). Of the 18 (51.4%) unacceptable differences in measurements obtained (i.e. difference $\geq$ 0.5 mm), there were 13 cases where the file tip was located shorter than (1 mm) away from the radiographic apex. There was no correlation ($p > .05$) between unacceptable difference in measurements between the two methods and status of the pulp (Table 2).

TABLE 1: ROOT CANAL LENGTHS IN PRIMARY ANTERIOR TEETH DETERMINED BY DIFFERENT METHODS

Methods	N	Mean ± SD (mm)	95% Confidence Interval	Range (mm)
Root ZX	35	13.757 ± 2.23	lower: 12.99	9.00-18.00
			upper: 14.52	
Length on RG	35	14.59 ± 2.321	lower: 13.79	9.50-11.5
			upper: 15.34	

TABLE 2: EFFECT OF THE PULP CONDITION ON THE ACCURACY OF ROOT ZX EAL

Measurement Difference (mm)	Total Frequency (%)	No. of Necrotic Canals (%)	No. of Vital Canals (%)	P Value
.5	17 (48.6)	7 (43.8)	10 (52.6)	0.467
1.0	13 (37.1)	7 (43.8)	6 (31.6)	0.782
1.5	5 (14.3)	2 (12.5)	3 (15.8)	0.655

DISCUSSION

Root ZX (EAL) has proven its accuracy in several in vivo and in vitro studies.[8,9,18,19] The present in vivo study adds to the current knowledge by providing data regarding the effect of pulpal status on the accuracy of the Root ZX (EAL) assessed in a standardized clinical conditions. The same operator did all the measurements, and was trained in using the device, hence, reducing the chance for operator bias. Though, to-date there are no studies showing the relation between operator's skills and the accuracy of these devices. However, it is crucial for the operator to have training and experience on how to use the EALs to ensure accurate measurements as also mentioned by Akisue et al (2007).[20] Other factors that were considered to obtain reliable data included the use of stainless steel K files while previous studies reported negative results using nickel-titanium files.[21,22] The reason may be attributed to how EAL functions, training/skills of the clinician, study design, the electrical characteristics of the walls of the root canal, alloys and mechanisms of the electric current conduction in the canal.[23] Also use of appropriate file size may affect the reliability of the measurement. Ebrahim et al (2006)[24] concluded that a file of a size close to the prepared canal diameter should be used for root length measurement. Moreover, Akisue et al (2007)[20] emphasized the use of the files compatible with root canal size.

In the current study, the Root ZX (EAL) showed similar accuracy (p> .05) in both vital and non-vital (necrotic) primary anterior teeth in the acceptable measurements group, in agreement with studies by Kim and Lee (2004) and Wrbas et al (2007).[16,17] However, some studies have shown a higher accuracy of EALs in measuring the root canal length in vital canals, when compared to necrotic ones.[25,26] Regardless of the pulpal status, the accuracy found in the acceptable group in this study is with agreement of other studies.[14,20,27-30]

In vital and necrotic teeth, the percentage of acceptable measurements was (48.6%), indicating that Root ZX can be used as an adjunct tool to radiographs for determining root canal length. However, considering the number of teeth in this study, it's believed that Root ZX would show higher accuracy with larger sample size. Renner et al (2012)[14] in a similar study like the present study found that pulp condition had no significant effect on the accuracy of the EAL, and that the EAL showed 73.61% agreement rate with those determined radiographically. However, their study included 144 canals of permanent teeth, which would explain the lower percentage of acceptable measurements obtained in the present study. Kolanu et al (2014)[31] studied the influence of critical diameter of apical foramen and file size using EAL in working length determination and found that the accuracy of the EAL decreases as apical foramen widens. So care should be taken when using it clinically in primary teeth.

The acceptable tolerance rate has a basic role in clinical situation, where it is almost impossible to precisely locate the apical constriction (ideal working length).[32] Beltrame et al (2011)[33] reported that Root ZX (EAL) was precise in 69% and 65% of the cases with and without root resorption, respectively (tolerance = ±0.5 mm) in vivo, and 69% and 77% ex vivo suggesting that Root ZX can be used as an assisting tool to the conventional radiographic method. Referring to ElAyouti and Lost (2006)[34] findings though the difference between the electronic and radiographic methods in root canal measurements would be affected in the laboratories investigations, it has no relevant clinical affect. The current study utilized the tolerance rate of ±0.5 mm, which is in agreement with the clinical studies of Akisue et al (2007)[14] and Renner et al. (2012)[20]

Almost half of the canals in this study were in the unacceptable measurements group. Inadequate instrumentation in pulp treatment increases the risk of root canal therapy failure particularly in teeth with preoperative periradicular lesion.[35] The possible cause for the short measurements that have been observed in the present study could be the use of the (±0.5 mm) tolerance rate as recommended by Kim and Lee (2004)

and Wrbas et al (2007).[16,17] Further studies are recommended in a larger sample utilizing different groups of teeth and keeping in view the factors such as irrigants utilized and extent of root resorption.

CONCLUSIONS

- The status (vital or necrotic) of the root canal had no significant effect on root canal length measurement by Root ZX (EAL).
- Based on the acceptable tolerance rate of ±0.5 mm, almost half of the studied root canals in maxillary single-root primary teeth showed acceptable difference between digital radiography and EAL in root canal length measurement.

REFERENCES

1 Tosun G, Erdemir A, Eldeniz A, Sermet U, Sener Y. Accuracy of two electronic apex locators in primary teeth with and without apical resorption: A laboratory study. Int Endod J 2008;10: 365-71.

2 American Academy of Pediatric Dentistry. Guideline on pulp therapy for primary and immature permanent teeth. Reference Manual 2009;6:212-19.

3 Kielbassa A, Muller U, Munz I, Monting J. Clinical evaluation of the measuring accuracy of ROOT ZX in primary teeth. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2003;95:94-100.

4 Kumar S, Chacko Y, Lakshminarayanan L. A simple model to demonstrate the working of electronic apex locators. Endodontology 2004;16:50-53.

5 Ingle J, Bakland L. Endodontics, 5th ed. Elsevier: Canada; 2002.

6 Katz A, Tamse A, Kaufman Y. Tooth length determination: A review. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1991;72:238-42.

7 Sunada I. New method for measuring the length of the root canal. J Dent Res 1962;41:375-87.

8 Kielbassa A, Muller U, Munz I, Monting J. Clinical evaluation of the measuring accuracy of Root ZX in primary teeth. Oral Surg Oral Med Oral Path Oral Radiol Endod 2003;95:94-100.

9 Ghaemmaghami S, Eberie J, Duperon D. Evaluation of Root ZX apex locator in primary teeth. Pediatr Dent 2008;30:496-98.

10 Angwaravong O, Panitvisai P. Accuracy of an electronic apex locator in primary teeth with root resorption. Int End J 2009;42:115-21.

11 Bashar A, Joshi R, Alam M. Accuracy of electronic apex locator for determining the root canal length in presence of blood - an in vitro study. Bangladesh Med J 2009;37:15-18.

12 He L, Hu T, Zhao H, Lin J, Li P. Effect of four different solutions on the accuracy of electronic apex locators. Shanghai Kou Qiang Yi Xue 2008;17:304-07.

13 Ebrahim A, Yoshioka T, Kobayashi C, Suda H. The effects of file size, sodium hypochlorite and blood on the accuracy of Root ZX apex locator in enlarged root canals: an in vitro study. Aust Dent J 2006;51:153-57.

14 Renner D, Grazziotin-Soares R, Gavini G, Barletta F. Influence of pulp condition on the accuracy of an electronic foramen locator in posterior teeth: an in vivo study. Braz Oral Res 2012;26: 106-11.

15 Saatchi M, Aminozarbian M, Noormohammadi H, Baghaei B. Influence of blood on the accuracy of Raypex 5 and Root ZX electronic aoramen locators: An in vivo study. Braz Dent J 2016;27:336-39.

16 Kim E, Lee S. Electronic apex locator. Dent Clin North Am 2004;48: 35-54.

17 Wrbas K, Ziegler A, Altenburger M, Schirrmeister J. In vivo comparison of working length determination with two electronic apex locators. Int Endod J 2007;40:133-38.

18 Katz A, Mass E, Kaufman A. Electronic apex locator: a useful tool for root canal treatment in the primary dentition. ASDC J Dent Child 1996;63:414-17.

19 Bodur, H, Odabaş M, Tulunoğlu Ö, Tinaz A. Accuracy of two different apex locators in primary teeth with and without root resorption. Clin Oral Invest 2008;12:37.

20 Akisue E, Gavini G, de Figueiredo J. Influence of pulp vitality on length determination by using the Elements Diagnostic Unit and Apex Locator. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2007;104:129-32.

21 Nekoofar M, Sadeghi K, Sadighi Akha E, Namazikhah M. The accuracy of the Neosono Ultima EZ apex locator using files of different alloys: an in vitro study. J Calif Dent Assoc 2002;30: 681-84.

22 Sadeghi S, Abolghasemi M. The accuracy of the Raypex5 electronic apex locator using stainless-steel hand K-file versus nickel-titanium rotary Mtwo file. Med Oral Patol Oral Cir Bucal 2010;15:788-90.

23 Gehlot P, Manjunath V, Manjunath M. An in vitro evaluation of the accuracy of four electronic apex locators using stainless-steel and nickel-titanium hand files. Restor Dent Endod. 2016;41: 6-11.

24 Ebrahim A, Wadachi R, Suda H. Ex vivo evaluation of the ability of four different electronic apex locators to determine the working length in teeth with various foramen diameters. Aust Dent J 2006;51:258-62.

25 Arora R, Gulabivala K. An in vitro evaluation of the Endex and RCM Mark II electronic apex locators in root canals with different contents. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1995;79:497-503.

26 Pommer O, Stamm O, Attin T. Influence of the canal contents on the electrical assisted determination of the length of root canals. J Endod 2002;28:83-85.

27 Mayeda D, Simon J, Aimar D, Finley K. In vivo measurement accuracy in vital and necrotic canals with the Endex apex locator. J Endod 1993;19:545-48.

28 Dunlap C, Remeikis N, BeGole E, Rauschenberger C. An in vivo evaluation of an electronic apex locator that uses the ratio method in vital and necrotic canals. J Endod 1998;24:48-50.

29 Lee S, Nam K, Kim Y, Kim D. Clinical accuracy of a new apex locator with an automatic compensation circuit. J Endod 2002;28:706-09.

30 Smadi L. Comparison between two methods of working length determination and its effect on radiographic extent of root canal filling: a clinical study. BMC Oral Health 2006;6:4.

31 Kolanu S, Bolla N, Varri S, Thummu J, Vemuri S, Mandava P. Evaluation of Correlation Between apical Diameter and File Size Using Propex Pixi Apex Locator. J Clin Diagn Res 2014;8:ZC18-20.

32 Kuttler Y. Microscopic investigation of root apexes. J Am Dent Assoc. 1955;50:544-52.

33 Beltrame A, Triches T, Sartori N, Bolan M. Electronic determination of root canal working length in primary molar teeth: an in vivo and ex vivo study. Int Endod J 2011;44,402-06.

34 ElAyouti A, Lost C. A simple mounting model for consistent determination of the accuracy and repeatability of apex locators. Int Endod J 2006;39:108-12.

35 Negishi J, Kawanami M, Ogami E. Risk analysis of failure of root canal treatment for teeth with inaccessible apical constriction. J Dent 2005;33:399-404.