Original Article

Braz J Oral Sci.
October/December 2009 - Volume 8, Number 4

Comparative analysis of the electronic and radiographic determination of root canal length of primary molars– an ex vivo study

Lucineide de Melo Santos[1]; José Ivo Limeira dos Reis[1]

[1] DDS, MSc, PhD, Adjunct Professor, Dental School, Federal University of Alagoas, Brazil

Abstract

Aim: To evaluate comparatively the radiographic and electronic root canal length determination in primary molars. **Methods:** 128 canals from 66 primary molars were selected. The root of each tooth was cut open on the occlusal face, and the real tooth length (RTL) was measured and the gold standard working length (WL) was determined by subtracting 1 mm from this measurement. The teeth were then placed in a plastic receptacle holding alginate and saline for the electronic determination of the root length using a Root ZX apex locator. The radiographic determination of the WL was obtained by subtracting 1 mm from the measurement highest cusp to the root apex appearing in the radiography. The data were analyzed statistically by the Chi-square test at a 5% significance level. **Results:** There was statistically significant difference ($p<0.05$) between each tested method and the gold standard. The Root ZX apex locator and the radiographic method presented satisfactory results in 75.78% and 54.68% of the cases, respectively. **Conclusions:** The Root ZX apex locator is a reliable method to determine the WL of primary teeth, since it showed greater accuracy than the radiographic method.

Keywords: Root ZX, radiography, root canal length measurement, primary molars.

Introduction

Although dental caries is well known disease, primary teeth with deep carious lesions reaching the root canals is still a reality in pediatric dentistry, especially in economically deprived regions, which makes root canal therapy on these teeth necessary[1]. In this context, pulpectomy is still an important treatment in primary molars when the root pulp, infected or not, is not vital or is irreversibly inflamed[2-3].

The determination of the working length (WL) is one of the earliest stages and is a crucial point of endodontic therapy[4-5], especially in primary teeth[6]. Estimating the exact length of the root canal during endodontic therapy is fundamental to avoid injuring the permanent successor tooth[6-7].

While the factors related to pulpal damage in primary and permanent teeth are similar, the clinical management of these teeth can be different, based mainly on the differences between the two types of teeth[8]. Several techniques have been proposed to determine root canal length, but the ideal procedure has yet to be identified. Radiography has been widely used in the determination of root length[1-2,7,9]. However, radiography may generate inaccurate results, since x-rays provide a two-dimensional image of a three-dimensional streucture[10]. It is impossible to see, for example, the buccolingual aspect due to the superposition of the dentin, cementum, cortical bone and alveolus[11]. Moreover, radiographic images may suggest the presence of instruments inside the canal when, in fact, they are outside it. Small degrees of resorption are not clearly visible radiographically, resulting in an increased risk of overinstrumentation and/or overobturation[2].

Received for publication: July 27, 2009
Accepted: November 9, 2009

Correspondence to:
Lucineide de Melo Santos
Faculdade de Odontologia-FOUFAL
Av. Lourival Melo Mota, s/n,
Tabuleiro do Martins - Maceió - AL,
CEP: 57072-970
E-mail: jilreis@uol.com.br

Electronic apex locators were developed in 1962[12], in an attempt to obtain more precise measurements for the determination of root length and to establish the apical limit of instrumentation, and have been widely used on permanent teeth since then[5,13-16]. The Root ZX apex locator (Morita*, São Paulo, Brazil) is a third-generation electronic device which can detect the smallest diameter of the root canal in both moist and dry conditions, and performs well on permanent teeth[17], even when these teeth present root resorption[18]. The literature does not indicate differences when using the locator in permanent and primary teeth. However, there are some limitations in evaluating the accuracy of apex locators in primary teeth, including millimeter measurements and visualizing the exact location of the file tip, particularly in resorbed primary teeth[19]. Moreover, the shape, dimension, and position of the root apex are often continuously altered[2]. Several studies have focused on evaluating the use of these devices in primary dentition[2,6-7,20-22], achieving accuracy rates of 64-96.7%. In view of the above considerations, this *ex vivo* study evaluated the electronic and radiographic determination of root canal length in primary molars comparatively with the measurement obtained by direct viewing of the endodontic file.

Materials and methods

This work was approved by the Research Ethics Committee of the Federal University of Alagoas (UFAL), under the protocol number 011436/2005-98.

Sixty-six primary molars with up to one third of root resorption were obtained from the Tooth Bank of the Dental School of Federal University of Alagoas, totalizing 128 canals. Molar roots with more than 1/3 apical resorption were excluded from this study. All the teeth showed some degree of root resorption. The root of each tooth was cut open on the occlusal face with carbide (Jet Brand; Wheeling, IL, USA) and Endo-Z burs (Dentsply-Maillefer, Ballaigues, Switzerland) mounted in a high-speed handpiece.

The real tooth length (RTL) was then measured using a magnifying glass (x2). A 21-mm-long size 10 K-file (Dentsply-Maillefer) was introduced into the canal until its tip appeared at the apical foramen, or at the point of root resorption, and this measurement was marked with a rubber stop at the height of the reference cusp. The file was then placed in a digital caliper (Mitutoyo, Tokyo, Japan) and the RTL was measured. This measure minus 1mm was recorded as the WL gold standard. The measurements were taken by a calibrated examiner and recorded on specific charts. Each tooth was measured three times, and the mean value was calculated.

The root canal length was determined electronically using a Root ZX (Morita, São Paulo, SP, Brazil) apex locator. For such purpose, the teeth were numbered 1 to 66 and embedded in alginate (Jeltrate; Dentsply Ind. e Com. Ltda., Rio de Janeiro, RJ, Brazil) with saline, which acts as a conductor simulating the periodontium[23]. The canals were then flushed with 2.5% sodium hypochlorite and dried with a paper point. The WL was measured with a size 10 K-file. All measurements were taken within a 2-h interval, when the gel was still sufficiently damp. The device was used according to the manufacturer's instructions. The lip electrode was attached to the alginate. The file was inserted slowly into the canal until the signal on the LCD screen display bar reached the apex signal. At this point, the instrument was removed gradually until it displayed a measurement of 1[21]. Measurements were considered valid if the instrument remained stable for at least 5s[20]. Each tooth was measured three times with the device and the mean value was calculated. All measurements were made by the same operator, who was blinded to the resorption stage of the teeth.

The WL was determined radiographically according to the paralleling technique) using an x-ray equipment operating at 8Ma and 70Kvp (Dabi Atlante*, Ribeirão Preto, SP, Brazil). A conventional dental x-ray film (Ektaspeed E-speed group; Kodak, Rochester, NY, USA) was placed perpendicular to the teeth, maintaining a 20 cm focus-film object and 0.4 exposure time. The WL was determined as follows: the length of the tooth was measured on the diagnostic radiographic image, from the highest cusp to the root apex, and 1 mm was subtracted from this length. The same procedure was employed in the case of curved roots. All measurements were taken by the same operator.

The electronically and radiographically measured WLs were compared with the gold standard WL and scores were attributed to the resulting values[24] (Table 1). Data were analyzed statistically by the Chi-square test at 5% significance level.

Table 1 – Working length scoring system.

Score	Situation
0	Working Length (WL) equal to gold standard
1	Working Length (WL) from 0.5 to 1mm shorter than gold standard
2	Working Length (WL) > 1mm shorter than gold standard
3	Working Length (WL) exceeds gold standard

Results

There was statistically significant difference ($p<0.05$) between the gold standard WL and the WLs obtained with the Root ZX and radiographic methods (Table2).

Table 2 – Means and standard deviations of the differences between the gold standard WL and the WL obtained with the Root ZX and radiographic methods

	Root ZX	Radiography
Mean	[a]0.14mm	[b]0.68 mm
Standard deviation	0.45	0.88
Number of canals	128	128

Different letters indicate statistically significant differences ($p<0.05$).

A comparison of the number and proportion of cases in which the WL measurements were scored 0 and 1 indicated a significant difference ($p<0.05$) between the two techniques, with the Root ZX method being statistically superior to radiography (Table 3). Comparison of the data referring to the number and proportion of cases in which the WL measurements fell between scores 2 and 3 also showed statistically significant difference ($p<0.05$) between the two techniques (Table 4).

Table 3 – Number of cases in which the electronically and radiographically measured WL fell between scores 0 and 1.

Groups	No. of cases	Total canals	Percentage (%)
Root ZX	97[a]	128	75.78
Radiography	70[b]	128	54.68

Different letters indicate statistically significant differences ($p<0.05$).

Table 4 – Number of cases in which the electronically and radiographically measured WL fell between scores 0 and 1.

Groups	No. of cases	Total canals	Percentage (%)
Root ZX	31[a]	128	24.21
Radiography	58[b]	128	45.31

Different letters indicate statistically significant differences (p<0.05).

Discussion

The correct determination of the length of root canals is essential to avoid injuring the permanent successor tooth during root canal therapy[6-7]. Most root canal length determination methods are based on radiographic examination[1-2,7]. However, radiographic images may lead to misinterpretations, since slight degrees of resorption may not be visible and the superposition of adjacent anatomical structures may impair the clarity of the image[9]. Moreover, the exposure of children to x-rays should be reduced[25]. Hence, the electronic method has been proposed as an alternative[2,7].

In the present study, the Root ZX device provided WL measures that were closer to the gold standard than those obtained with the radiographic technique. These data were confirmed in the comparison with the mean scores attributed to the differences of the measurements, since it was found that most measurements obtained radiographically were 1 mm shorter than the gold standard WL, while those obtained with the Root ZX device were closer with the gold standard. These findings are similar to several studies reported in the literature that evaluate the accuracy of the Root ZX method in primary teeth, which have demonstrated that electronic measurements are closer to the WL than those obtained radiographically[6-7, 9].

When the apical constriction is destroyed by apical root resorption, it is very difficult to determine the WL based only on an x-ray image, and the Root ZX method can be used in these cases[18]. It should be emphasized, at this point, that physiological[26] or pathological root resorption frequently occurring in primary teeth should not be seen as an obstacle preventing the use of electronic apex locators. Root resorption does not involve more than two thirds of the root; therefore, endodontic therapy is counter-indicated in these cases. The electronic apex locator can work accurately in primary teeth with root resorption because the root canal typically has a decreasing taper towards the defect[23]. In the present study, all teeth presented root resorption, though without affecting the performance of the Root ZX device, which confirms the findings of previous studies[2,6-7,19-20].

With regard to the number and proportion of cases when the WL measurements were the same or 0.5 to 1 mm shorter than the gold standard WL, it was observed that the Root ZX technique presented a higher percentage (75.78%) than the radiographic technique (54.68%), a statistically significant difference. These results are partially consistent with those obtained in previous studies[6-7]. By comparing radiographic and electronic measurements to determine the root canal length, Katz et al.[7] and Subramaniam et al.[9] found no significant difference between the methods, although the x-ray based measurements were higher than those obtained with the Root ZX device. A probable explanation for this difference in results lies in the methodology used in the present research, which established scores to evaluate the data obtained, unlike the cited studies. Some studies investigating the accuracy of electronic apex locators in permanent teeth have shown that the accuracy of the Root -ZX device varied from 75 to 82.3%[5, 27].

The proportion of cases in which the WL measurements were more than 1 mm shorter or longer than the gold standard WL was different, although the Root ZX method presented superior results. This means that the use of the electronic apex locator enabled us to obtain WL measurements that are closer to the gold standard WL and shorter than the apical foramen or the earliest stages of resorption. Considering that the objective of the endodontic therapy in primary teeth is to eliminate infection and keep the tooth functional until its physiological exfoliation, without compromising the permanent successor[28], it can be inferred that the radiographic technique is less accurate than the Root ZX technique, since it presented a higher proportion of cases in which the WL was more than 1 mm shorter than the gold standard WL.

It may be concluded that the Root ZX locator is a reliable method to determine the WL of primary teeth, since the Root ZX method showed s smaller difference from the gold standard in determining the acceptable WL than the radiographic method.

References

1. Garcia–Godoy F. Evaluation of an iodoform paste in root canal therapy for infected primary teeth. J Dent Child. 1987; 54: 30-4.
2. Mente J, Seidel J, Buchalla W, Koch MJ. Eletronic determination of root canal length in primary teeth with and without root resorption. Int Endod J. 2002; 35: 447-52.
3. Rodd HD, Waterhouse PJ, Fuks Ab, Fayle SA, Moffat, MA. Pulp therapy for primary molars. Int J Paediatr Dent. 16 (suppl.1): 2006; 15-23.
4. Ingle JI, Beveridge EE. Endodontics. 2a ed. Philadelphia: Lea & Febiger; 1976.
5. Wrbas KT, Ziegler AA, Altenburger M.J., Schirrmeister J.F. In vivo comparison of working length determination with two electronic apex locators. Int Endod J. 2007; 40: 133-8.
6. Kielbassa AM, Muller U, Munz I, Monting JS. 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.
7. Katz A, Mass E, Kaufman AY. Eletronic apex locator: a useful tool for root canal treatment in the primary dentition. J Dent Child. 1996; 63: 414-7.
8. Koshy S, Love RM. Endodontic treatment in the primary dentition. Aust Endod J. 2004; 30: 59-68.
9. Subramaniam P, Konde S, Mandanna DK. An in vitro comparison of root canal measurement in primary teeth. J Indian Soc Pedod Prev Dent. 2005; 23: 124-5.
10. Pineda F, Kuttler Y. Mesiodistal and buccolingual roentgenographic investigation of 7.275 root canals. Oral Surg Med Oral Pathol. 1972; 33: 101-10.
11. Gupta D, Grewal N. Root canal configuration of deciduous mandibular first molars - An in vitro study. J Indian Soc Pedod Prev Dent. 2005; 23: 134-7.
12. Sunada I. New method for measuring the length of the root canal. J Dent Res. 1962; 41: 375-87.
13. Kaufman AY, Fuss Z, Keila S, Waxenberb S. Realibility of different electronic apex locators to detect root perforations in vitro. Int Endod J. 1997; 30: 403-7.
14. Ebrahim AK, Wadachi R, Suda H. In vitro evaluation of the accuracy of five different electronic apex locators for determining the working length of endodontically retreated teeth. Aust Endod J. 2007; 33: 7-12.
15. 1Williams CB, Joyce AP, Roberts S. A comparison between in vivo radiographic working length determination and measurement after extraction. J Endod. 2006; 32: 624-7.
16. D'Assunção FL, Albuquerque DS, de Queiroz Ferreira LC. The ability of two apex locators to locate the apical foramen: an in vitro study. J Endod. 2006; 32: 560-2.
17. Pagavino G, Pace R, Baccetti T. A SEM study of in vivo accuracy of the Root ZX electronic apex locator. J Endod. 1998; 24: 438-41.
18. Goldberg F, De Silvio AC, Manfré S, Nastri N. In vitro measurement accuracy of an eletronic apex locator in teeth with simulated apical root resorption. J Endod. 2002; 28: 461-3.
19. Leonardo MR, Silva LAB, Nelson-Filho P, Silva RAB, Lucisano MP. Ex vivo accuracy of an apex locator using digital signal processing in primary teeth. Pediatr Dent. 2009: 31: 320-2.
20. Tosun G, Erdemir A, Eldeniz AU, 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; 41: 436-41.
21. Leonardo MR, Silva LAB, Nelson-Filho P, Silva RAB, Raffaini MSGG. Ex vivo evaluation of the accuracy of two eletronic apex locators during root canal length determination in primary teeth. Int Endod J. 2008; 41: 317-21.

22. Angwaravong O, Panitvisai P. Accuracy of electronic apex locator in primary teeth with root resorption. Int Endod J. 2007; 42: 115-21.
23. Ounsi HF, Haddad G. In vitro evaluation of the reliability of the Endex electronic apex locator. J Endod. 1998; 24: 120-1.
24. Menezes JVNB. Estudo in vitro do grau de fidelidade de técnicas de odontometria em molares decíduos [Master's thesis]. Florianópolis: Universidade Federal de Santa Catarina; 1999.
25. Bagett FJ, Mackie IC, Worthington HV. An investigation into the measurement of the working length of immature incisor teeth requiring endodontic treatment in children. Br Dent J. 1996; 181: 96-8.
26. Harokopakis-Hajishengallis E. Physiologic root resorption in primary teeth: molecular and histological events. J Oral Sci. 2007; 49: 1-12.
27. Tselnik M, Baumgartner JC, Marshall JG. An evaluation of root ZX and elements diagnostic apex locators. J Endod. 2005; 31: 507-9.
28. Reddy S, Ramakrishna Y. Evaluation of antimicrobial efficacy of various root canal filling materials used in primary teeth: a microbiological study. J Clin Pediatr Dent. 2007; 31: 193-8.