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## Accuracy of three different apex locators and visual exam in primary teeth with and without root resorption *in vitro*

### ABSTRACT

**Aim** The aim of this study was to evaluate the accuracy and reliability of three apex locators (EndoMaster, Raypex, DentaPort ZX) and visual assessment in primary molar teeth *in vitro*.

**Materials and methods** Twenty-four extracted human primary molar teeth with and without root resorption were used in this study. After endodontic access preparation, root canal length was visually measured by means of a K file; then the teeth were embedded into alginate and the roots were measured again by means of the three apex locators. The results were collected in SPSS 15.0 and statistical evaluations were completed by one-way ANOVA and Kruskal-Wallis test.

**Results** The measurements closest to the visually determined length were obtained with EndoMaster. No statistically significant differences were found between visual and apex locators lengths ( $p > 0.05$ ).

**Conclusion** Within the limitations of this study, the use of apex locators would be useful in the endodontic treatment of primary teeth.

**Keywords** DentaPort ZX; EndoMaster; Primary teeth; Raypex.

## Introduction

Removing the pulp tissues from the root canal is essential for endodontic treatment both in permanent and primary teeth. However, it is sometimes a difficult procedure for paediatric dentists but the main goal is to provide comfort to the patients. Endodontic treatment to primary teeth can be difficult because of the patient's poor cooperation, limited access, anatomical variations, and complex anatomy of the roots, and so extractions are sometimes recommended. Early loss of primary teeth or an untreated endodontic pathology can cause some problems.

The root anatomy of primary teeth can vary because it resorbes during eruption of their permanent successors. An important stage of the endodontic treatment is the determination of the working length both in permanent and primary teeth [Nelson-Filho, 2011], and it is also crucial due to the presence of the successors and to avoid periapical injuries. Tactile sensitivity, paper points and conventional radiographs are methods for the determination of root canal length [Subramaniam, 2005]. Radiography is traditionally used to obtain information about the root canal anatomy, working length and the surrounding apical tissues [Mello-Moura, 2010; Leonardo, 2008; Odabas, 2011]. On the other hand, radiographs have limitations and disadvantages such as poor cooperation, limited access to the mouth of children, increased appointment time, exposure of the patients to ionizing radiation. In addition, the radiographic method is technique-sensitive and subjected to the operator's interpretation and quality issues like distortion and magnification [Chakravarthy Pishipati, 2013; Krishnan, 2012; Angwaravong, 2009; Mente, 2002; Kielbassa, 2003; Bodur, 2008]. Another disadvantage of the radiograph is that it provides a two-dimensional image of a three-dimensional object [Lucineide de Melo Santos, 2009] and it does not show the buccolingual aspect of the canals as a result of the superimposition of other tissues such as dentin, cementum and cancellous and cortical bone of the alveolus [Odabas, 2011; Gupta, 2005]. Radiographic assessment of small areas of resorption is difficult, particularly in cases where resorption occurs on buccal or lingual aspects of the root. The results of a microscopic study showed that the major foramen may be located up to 3.5 mm from the radiographic apex [Kocak, 2013; Mente, 2002; Nelson-Filho, 2011].

There are few methods for determining the working length like paper points technique and average root measurements but these techniques are not standardized and have to be considered as adjunct methods. The dentist should determine the working length correctly to avoid over instrumentation and obturation [Nelson-Filho, 2011; Angwaravong, 2009; Mente, 2002; Orafi, 2013; Rosenberg, 2003].

For over 40 years, electronic apex locators have been

used in permanent teeth endodontic treatments and the devices of new generation have gained popularity [Leonardo, 2008; Angwaravong, 2009; Bodur, 2008]. The use of electronic apex locators (EAL) in primary teeth is not universally accepted [Beltrame, 2011]. Despite some limitations in evaluating the accuracy of apex locators in primary teeth, including millimeter measurements and visualization of the exact location of the file tip, particularly in resorbed primary teeth [Leonardo, 2009] the *in vitro* and *in vivo* studies made with primary teeth recommend using electronic apex locators in primary teeth endodontic treatment with or without root resorption. The literature does not indicate differences when using apex locators in permanent and primary teeth [Leonardo, 2009] and concluded that electronic apex locators are safe, painless, and useful because they avoid unnecessary exposure to radiations. Therefore, they are recommended for use in primary teeth [Subramaniam, 2005; Mente, 2002; Kielbassa, 2003; Bodur, 2008; Katz, 1996; Patino-Marin, 2011; Ghaemmaghami, 2008].

The aim of this study was to evaluate the accuracy of three electronic apex locators (EndoMaster, Raypex and DentaPort ZX) and visual examination during root canal length determination in primary teeth *ex-vivo*.

## Materials and methods

Consents were obtained from the parents to collect the extracted teeth and use them in *in vitro* studies. Twenty-four extracted human primary molar teeth with and without resorption were collected and stored in saline solution at 4 °C. Teeth with root fractures and having more than 1/3 root resorption were excluded from the study, therefore the final sample was composed of 51 roots.

All root surfaces were cleaned to remove organic debris and deposits. The cusps were flattened with a tapered diamond bur using a high-speed handpiece under water irrigation to establish a levelled surface to serve as a stable, unequivocal reference for all measurements. Following endodontic access cavities preparation, a size 15 K-file of diameter compatible with that of the canal diameter was passively introduced up to the apical foramen or to the most coronal limit of root resorption to verify canal patency without performing a canal preparation. A K-file with a silicone stop was passively introduced into the root canal until its tip was visible at either the apical foramen or the apical resorption level and then withdrawn 1 mm to measure the visual length. The reference point was marked with a fine point marker to facilitate accurate reinsertion of the files. All measurements were made by two examiners.

After determining the visual length, the primary teeth were embedded in an alginate model developed to test

apex locators. The alginate was poured into a plastic box, and teeth and lip-clip electrode were embedded in the alginate. The root canals were irrigated with 5% sodium hypochlorite. Excess hypochlorite was removed using a cotton pellet. The electronic measurement of the root was made with EndoMaster (EMS, Nyon, Switzerland), Raypex (VDW, Munich, Germany), and DentaPort ZX (J. Morita Mfg. Corp., Kyoto, Japan) respectively. Measurements were considered valid if the instrument remained stable for at least 5 s.

### Statistical analysis

SPSS software version 15.0 (SPSS Inc., Chicago, IL, USA) was used for statistical evaluations. Cohen's kappa statistic was also used for inter-examiner agreement. One-way ANOVA was used for comparing the exact lengths (visually determined length and electronic lengths), and the Kruksal-Wallis test was used for comparing the accuracy of the measurement with each apex locator at the confidence interval of 95%.

## Results

Inter-examiner kappa value was 0.99 (perfect agreement).

When comparing the accuracy of the measurement, results were as follows: visually determined length>EndoMaster>Raypex>DentaPort ZX ( $p>0.05$ ) (Table 1). The measurements closest to the visually determined length were obtained with EndoMaster.

No statistically significant differences were found for each measurement ( $p>0.05$ ) (Table 2). All tested apex locators showed acceptable accuracy levels. EndoMaster showed more accurate measurements (56.9%) than Raypex (51%) and DentaPort ZX (45.1%).

## Discussion

Determining the root length is a crucial step in endodontic treatment and it is more important in primary teeth because of the presence of the successor teeth [Leonardo, 2008; Kielbassa, 2003; Bodur, 2008; Katz,

Groups (n=51)	Exact lengths (mean±SD)
Visually-determined length	13.91±1.74
Endo Master	13.88±1.88
Raypex	13.76±1.77
DentaPort ZX	13.64±1.68

TABLE 1 Measured root lengths.

No significant differences were found among groups

Variances in measurement (electronic length-visually determined length)	Number and frequency of variance in measurements		
	Endo Master (n=51)	Raypex (n=51)	DentaPort ZX (n=51)
- 1 mm	4(7.8%)	10(19.6%)	12(23.5%)
- 0.5 mm	9(17.6%)	7(13.7%)	8(15.7%)
Correct	29(56.9%)	26(51%)	23(45.1%)
+0.5 mm	3(5.9%)	4(7.8%)	4(7.8%)
+1 mm	6(11.8%)	4(7.8%)	4(7.8%)

\*No significant differences were found between groups

TABLE 2 Number and frequency of variance in measurements for all apex locators.

1996]. Most canal length determination methods are based on radiographic examination but there are some limitations. The accurate radiographic determination of the root canal length is limited because of anatomical variations, interference of anatomical structures or errors in projection. Minor degrees of resorption may not be radiographically obvious and these may lead to over instrumentation and overfilling [Nelson-Filho, 2011; Angwaravong, 2009; Mente, 2002]. Another limitation of the radiographic examination is that radiographs provide a two-dimensional image of a three-dimensional object (tooth), leading to distortions and mistakes in measurement of the working length [Odabas, 2011]. Although it was reported that the location of the apical foramen could be accurately determined radiographically, the distance between the apical constriction and the apical foramen cannot be measured when the latter is located lingually or buccally. It is also very difficult to obtain intraoral radiographs to measure the root canal length because of poor cooperation and limited access to the mouth of children [Kielbassa, 2003]. Moreover, radiographic determination of root canal length may give misleading results when lateral canals are present. One of the critical aspects of pulpectomy in primary teeth is the presence of root resorption and minor degrees of resorption may not be radiographically obvious and more extensive resorption should be considered as a contraindication for root canal treatment [Mente, 2002].

The radiographic examination depends on the operator's skills, the child cooperation and the access to child's mouth; a mistake in this step will lead to unwanted exposure to radiation. Because of these reasons, radiography has important limitations in the estimation of the exact length of primary teeth root canals [Subramaniam, 2005; Mente, 2002; Bodur, 2008; Katz, 1996; Patino-Marin, 2011; Ghaemmaghami, 2008; Neena, 2011]. The use of apex locators can overcome these limitations and disadvantages.

In an *in vitro* study the extracted teeth should be

immersed in a medium that has similar electrical resistance to that of the periodontium. The alginate model was used in this study to duplicate the periodontium and for each apex locator the instrument remained stable at least 5s to obtain an accurate measurement.

The use of the electronic devices to determine the working length has gained popularity and they are now widely used in clinical practice. It is a safer, cheaper and quicker compared to radiographic examination [Beltrame, 2011]. *In vitro* studies on primary teeth showed the reliability of apex locators: studies comparing radiographic examination and apex locator have found that apex locators are reliable for determining the working length [Krishnan, 2012]. In the present study, the accuracy of three apex locators and visual examination was compared and no statistically significant differences were found; the results closer to visual examination were obtained with Endomaster, Raypex and DentaPort ZX respectively.

Katz et al. [1996] found that radiographic measurements were longer (0.4 mm–0.7 mm) than those obtained with apex locator. The results of our study differ, since the apex locator's findings varied from -1mm to +1mm.

Ideally the root canal should be instrumented up to the cemento-dentinal junction or the apical constriction. Studies showed that the distance between the apical major foramen and the minor foramen varied 0.5-1 mm for teeth of different ages [Tosun, 2008]. Moreover, root resorption destroys the apical constriction. Therefore, it is difficult to determine the working length with radiographs but 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 [Santos, 2009]. Because of the physiological and pathological resorptions of the apical constriction, some authors considered that a  $\pm 0.5$  mm variance is acceptable, while others deem  $\pm 1$  mm more appropriate [Angwaravong, 2009; Kielbassa, 2003;

Bodur, 2008; Beltrame, 2011]. In this study, the accuracy of the three apex locators was assessed by taking into account these variances ( $\pm 0.5$  mm and  $\pm 1$  mm). There were no statically significant differences between visual examination and the three apex locators.

Pascon et al. [2009] and Miletic et al. [2011] found no statistically significant differences between DentaPort ZX and Raypex in their study and these results were similar to the present study. In contrast to our results, Stoll et al. [2010] evaluated four apex locators and found a higher accuracy for DentaPort ZX. The tested apex locators (EndoMaster, Raypex and DentaPort ZX) proved useful and could be able to determine the working length in primary molar teeth with and without resorption. The percentage of correct measurements with EndoMaster, Raypex and DentaPort ZX were 56.9%, 51% and 45.1% respectively. In the range  $\pm 0.5$  mm the accuracy of the locators was as follows: EndoMaster 80.4%, Raypex 72.5% and DentaPort ZX 68.6% but there were no statically significant differences between visual exam and apex locators. It is important to mention that the values of the tested locators were in the limit of  $\pm 1$ , however for most authors these are acceptable values. On the other hand, the tested apex locators do not seem able to replace the radiographic examination.

## Conclusion

The apex locators Endomaster, Raypex and DentaPort ZX were able to determine accurately the root canal length and can be recommended for use in primary teeth, however further *in vivo* researches are necessary.

Paediatric dentist sometimes extract primary teeth instead of performing a root canal treatment, and apex locators would facilitate and shorten the process. This paper shows that apex locators could be safely used in primary teeth because there would be no need for repeated radiographs.

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