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JSM Dentistry

Research Article

An *Ex vivo* Behavior of Siroendo Pocket Eletronic Apex Locator in Primary and Permanent Molars

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Submitted: 05 August 2014

Accepted: 16 October 2014

Published: 18 October 2014

ISSN: 2333-7133

Abstract

Aim: The aim of the present study was to evaluate *ex vivo* the accuracy of SIROEndo Pocket electronic apex locator (EAL) for working length determination in permanent molars and primary incisors with and without physiological root resorption.

Methods: One calibrated examiner determined the working length in 21 primary incisors either with or without physiological apical resorption and also in 14 permanent molars. Working length was measured both visually, with the placement of a #15 K-file 1 mm short of the apical foramen or the apical resorption bevel, and electronically, using the EAL according to manufacturers' instructions.

Statistics: Data were analysed statistically using the intraclass correlation test.

Results: Comparison of the real and the electronic measurements revealed high correlation between the methods, regardless tooth type and presence or absence of physiological root resorption. For primary teeth without root resorption, the means were 15.75 mm and 15.66 mm for direct (real) and electronic (SIROEndo Pocket) working length measurements, respectively. Similarly, for primary teeth with root resorption, the means were 12 mm and 11.61 mm for direct and electronic working length measurements, respectively. Permanent teeth evaluation showed means values of 20.75 mm and 21.3 mm for direct and electronic working length measurements, respectively.

Conclusion: SIROEndo Pocket was proven comparable the direct mode for apical foramen location for working length measurement in permanent and primary teeth.

INTRODUCTION

During endodontic treatment, correct establishment of the root canal length is critical to complete removal of infected tissues, thorough canal cleaning, shaping, disinfection, and hermetic sealing of the root canal [1]. Indeed, the correct working length determination is important to avoid over-filling or under-filling, increasing the chances of endodontic treatment failure. It is especially critical in primary teeth, whilst overinstrumentation and overfilling can damage the germ of the permanent tooth. Underfilling, on the other hand, is also a risk factor that accounts for persistence of apical infection [2].

Traditionally, tactile sense and conventional periapical radiographic methods have been used to determine the apical foramen. However, tactile sense is empirical and the radiography can only provide a two-dimensional image of a three-dimensional object [3,4]. Also, radiographic assessment has limitations due to anatomic variations of the canal system, interference of adjacent anatomic structures or technical errors in projection [5,6]. In addition, in most cases, the apical foramen does not coincide with the radiographic apex, which may lead to incorrect working length determination.

Additionally, these methods for the determination of root canal length may yield inaccurate information, particularly in primary teeth, in cases with root resorption [7]. Particularly in pediatric dentistry, children's acceptance and cooperation for radiographic examination is usually achieved with difficulty, and so a method that could minimize the need for exposing paediatric patients to radiation during this part of root canal therapy would be welcomed.

All these factors together have stimulated the development of electronic root canal length measuring devices, the so-called electronic apex locators (EALs), which accurately report the foramen or, more precisely, locate the position of the apical constriction.

Most studies have focused on the investigation into these new technologies for determining the root canal length in permanent teeth [8-13]. The high precision rates achieved in these studies have increased their popularity and motivated their clinical use. However, in primary dentition, a few studies had evaluated these devices for determination of canal working length [7,14-17] evaluated *ex vivo* the accuracy of the multifrequency electronic apex locator (EAL) Joypex 5 in primary molars, and they concluded that there was no significant difference in between the direct observation and the EAL measurement ($p < 0.05$). The ICC confirmed the agreement of different methods to measure canal length [17].

It is possible to find in the literature data that supports the potencial use of EALs in primary teeth [Ahmed, 2013], [18] regardless the stage of root resorption however, there are no studies evaluating the SIROEndo Pocket EAL for electronic measurement of working length.

Therefore, the purpose of this study was to evaluate *ex vivo* the accuracy of SIROEndo Pocket EAL for working length determination in permanent molars and primary incisors with and without physiological root resorption.

MATERIAL AND METHODS

Tooth selection and preparation

Maxillary and mandibular teeth (primary and permanent) were obtained from the Human Tooth Bank of the Ribeirão Preto School of Dentistry, University of São Paulo (Brazil). Primary teeth either without physiological apical resorption or with resorption up to half of the root, identified by visual evaluation were used. Preliminary radiographs were taken to evaluate root canal anatomy, identify the radiographic apex and exclude teeth with calcification, whose main canal was not visible radiographically. The roots were numbered and stored in sterile saline until use. Primary incisors extraction was done as a result of prolonged retention (no spontaneous exfoliation), orthodontic purposes or no possibility of restoration after caries excavation. Twenty one primary incisors were selected. A total of 14 permanent teeth extracted for periodontal, orthodontic, or prosthetic reasons were also selected for this study (total of 33 root canals).

After endodontic access cavity preparation, a #15 K-file was passively introduced up to the apical foramen to verify canal patency. No root canal preparation was performed.

Direct (real) determination of working length

For direct (real) measurement of working length, a reference point was first marked at the most coronal portion of the tooth crown using a fine paint marker. Then 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. The K-file was held by a needle-holder perpendicular to the edge defined as the reference point and was laid against an endodontic rule in order to measure the working length. The measure was approximate to the nearest half millimetre (Figure 1).

Electronic determination of working length

The electronic working length determination was undertaken using SIROEndo Pocket apex locator (Sirona Dental GmbH, Salzburg, Austria). Primary and permanent teeth were individually fixed in a sponge soaked in saline and the root canals were also filled with saline. Cotton pellets were used to remove excess saline from the pulp chamber. A low-impedance lip-clip electrode was attached to the sponge and the EAL was used according to the manufacturers' instructions. The file holder was clipped to the metal shaft of the K-file, and the device was adjusted to react when the file advanced into the root canal reached a point 1 mm short of either the root apex or the apical resorption bevel, that is, the point where the display read 1. The choice for using the "1" reading on the apex locator's display was based on the results of a previous pilot-study (data non showed), in which this reading presented the best correlation with the actual root canal length measurement (direct method) at 1 mm short of the root apex (Figure 2).

Statistical analysis

The measurements (in mm) of direct and electronic determination of the working length were made by an experienced calibrated examiner (kappa = 0.9), and were recorded in specific charts for further comparison of the methods. Data were analysed statistically using the intraclass correlation coefficient (ICC).

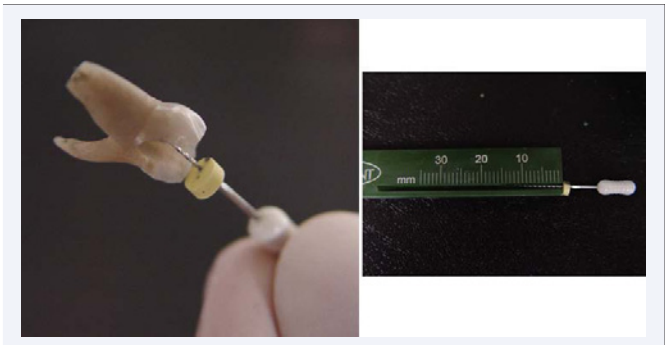

Figure 1 Determination of the working length by the direct method.

Figure 2 Determination of the working length by the electronic method.

RESULTS

Table 1 presents the working length measurements obtained with direct visualization and SIROEndo Pocket EAL in all primary teeth. Additionally, (Table 2) presents results related to all root canals from permanent molars evaluated in the study. In relation to primary teeth without root resorption, the means were 15.75 mm and 15.66 mm for direct (real) and electronic (SIROEndo Pocket) working length measurements, respectively. Similarly, primary teeth with root resorption, the means were 12 mm and 11.61 mm for direct (real) and electronic (SIROEndo Pocket) working length measurements, respectively. Permanent teeth evaluation showed means values of 20.75 mm and 21.3 mm for direct (real) and electronic (SIROEndo Pocket) working length measurements, respectively. Figures 3 and 4 compares graphically the real and electronic working length measurements related to primary and permanent teeth, respectivelly. The figures show a high intraclass correlation between the direct and electronic methods, regardless of the type of tooth (primary or permanent teeth), and the presence or absence of physiological root resorption related to primary dentition.

DISCUSSION

Radiographic method, traditionally the most popular and trusted way for length measurement in the endodontic field, has advantages like direct observation of the anatomy of the root canal system, number and curvature of roots, presence or absence of periapical pathologies and, in addition, acts as an initial guide for working length estimation [19]. There are, however, a number of disadvantages that make this technique not quite suitable in every situation such as, for example, the danger of overestimation of the root canal length even when it seems to be short of the radiographic apex because of normal anatomic variations in the apical region [20]. Other shortcomings of radiographs include technique sensitivity and subjectivity [21,22] the danger of ionizing radiation [23], and errors of superimposition caused by producing a two-dimensional representation from a three-dimensional object [5].

The development and production of electronic devices for locating the canal terminus have been major innovations in root canal treatment. The use of electronic working length determination has increased considerably in recent years, not only in the permanent [8-13,24] but also in the primary dentition [14,25-28,2,15,29,30]. The accuracy of the electronic measurements obtained in the present study with SIROEndo Pocket was similar to that reported by other authors using different EALs in primary teeth without physiological root resorption and permanent teeth [9,2,13,15]. In the present study, the results of SIROEndo Pocket showed high correlation with those of the direct method.

Table 1: Direct (real) and electronic working length measurements in 21 primary incisors.

Tooth	Direct method (mm)	SIROEndo (mm)
1	11	8
2	15	15,5
3	13	13
4	13	13
5	13	12
6	12	12
7	12	12
8	9	9
9	10	10
10	15	15
11	13	13
12	19	19
13	12	12
14	14	13
15	14	14
16	21	21
17	18	18
18	16	15
19	14	14
20	18	19
21	15	15

* Specimens from 1 to 9 represent teeth with physiological root resorption; specimens from 10 to 21 represent teeth without physiological root resorption

Table 2: Direct (real) and electronic working length measurements in all 33 root canals of permanent molars.

Tooth	Direct method (mm)	SIROEndo (mm)
1	19	20
2	21	21
3	20	20
4	21	21
5	21	21
6	21	21,5
7	19,5	20
8	20,5	20,5
9	22	22,5
10	23	23
11	23	23
12	22,5	22,5
13	18,5	21
14	18,5	20
15	19	19
16	16	18
17	17	17
18	18	17
19	22	21,5
20	21	21
21	21	21
22	21,5	21,5
23	21	21
24	23,5	23,5
25	24	24
26	24	24,5
27	20,5	21
28	21	21,5
29	22	22
30	21,5	22
31	20	20
32	20,5	21
33	21	20,5

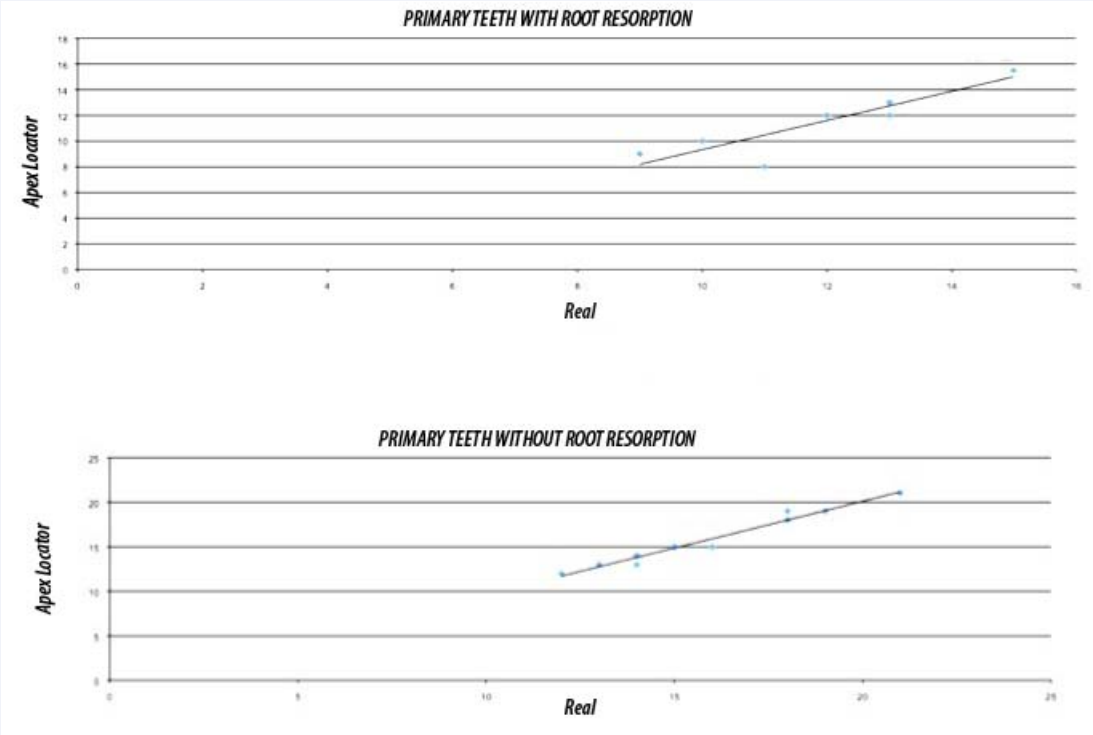

Figure 3 Real (direct measurement) and electronic (SIROEndo apex locator) root canal length measurements in the primary incisors with or without physiological resorption. The intraclass correlation represents the intersection of the two measurements that are indicated on the axes X (direct measurement) and Y (electronic measurement). The dots that coincide with the line represent that the two measurements had the same values.

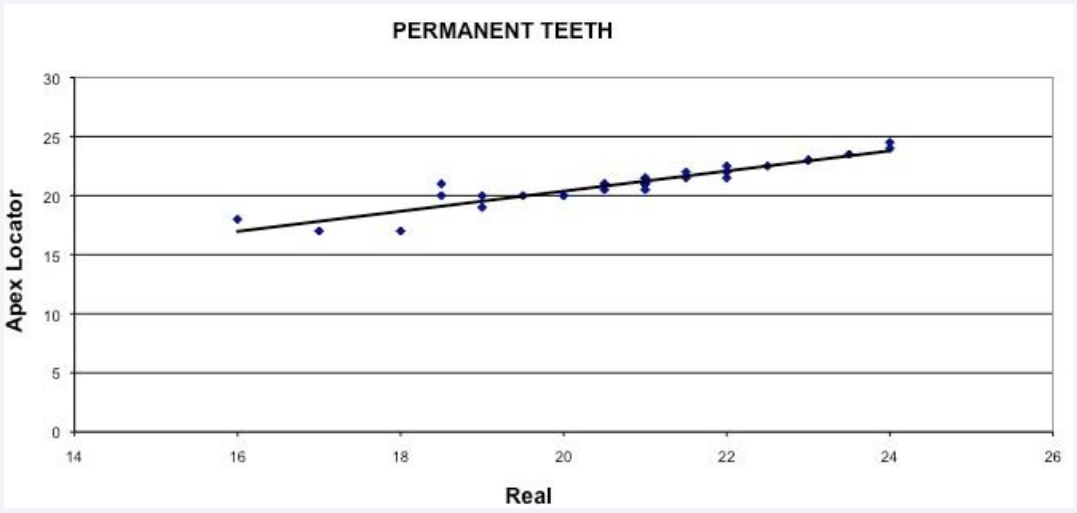

Figure 4 Real (direct measurement) and electronic (SIROEndo apex locator) root canal length measurements in the permanent root canals. A.

Regarding primary teeth with physiological root resorption, in our study, after using SIROEndo Pocket EAL, ICC value slightly decreased. This result was similar to that reported by Nelson-Filho and collaborators which evaluated Digital Signal Processing EAL in primary teeth with root resorption (ICC=0,82) [16].

The primary teeth have some particularities, such as the presence of the phisiological resorption bevel, extended accessories canals, and exposed dentinal tubules due to physiological root resorption, among others. All this factors could interfere on the electrical resistance of the root, promoting changes on the electronic measures. However, many authors agree that the use of EALs in primary teeth is very safe, reliable and recommended [18].

Wankhade and collaborators (2013) also evaluated the root canal length of deciduous teeth with or without resorption. The authors compared the canal length through several methods (EAL, radiographs, tactile sensation and radiovisiography) in relation to the gold standard (actual root canal length). They have

found that the mean determined by EAL, both in deciduous teeth without or with root resorption was closest to that of the actual root canal length.

Another study evaluating the use of EALs in primary teeth has found that Root ZX II seems to be a reliable device for obtaining the root canal length in primary maxillary incisor teeth and can be used as an alternative to radiographic technique [29].

Regarding the use of EALs for measurement of working length of permanent teeth, some authors have found that the electronic method was more accurate than the radiographic method, in vivo [24] and in vitro [31].

It is important to mention that the promising results of ex vivo studies do not imply that radiographs can be replaced by the use of the EALs. The use of EALs is a valuable tool for complementing and/or assisting radiographic methods of working length determination, and may reduce the number of radiographs required during endodontic therapy [3]. EALs used alone without the radiographic method cannot give any information about the curvature and direction of the root canal. Radiographic assessment after electronic root canal measurement confirms the root canal pathway because the image of the file within the canal facilitates the observation of a number of anatomical details. In addition, ex vivo studies do not include the errors that may occur whilst measuring working length in the mouth under clinical conditions.

Thereby, further studies with this multi-frequency root canal length measuring device under different conditions should be done to confirm its reliability for clinical indication.

CONCLUSION

In conclusion, in this *ex vivo* study, the SIROEndo Pocket EAL was comparable the direct mode to determine the working length in permanent and primary teeth with and without physiological root resorption.

ACKNOWLEDGMENTS

The authors thank Dra. Maria Conceição Pereira Saraiva, Professor of Epidemiology from the Department of Paediatric, Preventive and Community Dentistry, Ribeirão Preto School of Dentistry, University of São Paulo (Ribeirão Preto, São Paulo, Brazil) for statistical assistance. Also, we thank Dr. Mário Roberto Leonardo for his substantial assistance.

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Cite this article

da Silva RAB, de Queiroz AM, Nelson-Filho P, de Oliveira KMH, de Oliveira SS, et al. (2014) An Ex vivo Behavior of Siroendo Pocket Eletronic Apex Locator in Primary and Permanent Molars. JSM Dent 2(5): 1045.