

Original Research Article

Accuracy evaluation of three electronic apex locators in teeth with immature apices

Bruno Martini Guimarães¹
Marcelo de Moraes Vitoriano¹
Claudio Maniglia-Ferreira²
Fabio de Almeida-Gomes²
Marina Angélica Marciano¹
Clovis Monteiro Bramante¹
Marco Antonio Hungaro Duarte¹

Corresponding author:

Bruno Martini Guimarães
Al. Octavio Pinheiro Brisola, 9-75 – Vila Universitária
CEP 17012-901 – Bauru – SP – Brasil
E-mail: brunomgui@usp.br

¹ Department of Endodontics, School of Dentistry of Bauru, University of São Paulo – Bauru – SP – Brazil.

² School of Dentistry, University of Fortaleza – Fortaleza – CE – Brazil.

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Abstract

Introduction and Objective: The aim of this randomized controlled study was to evaluate the accuracy of Root ZX, iPex and YS-RZ-A apex locators in tooth with incomplete apices. **Material and methods:** Thirty human mandibular pre-molars without dental caries, fracture and with 1-3mm apical diameter and $\frac{3}{4}$ of root development stage were used. After coronal access, tooth length was determined with the visualization of a K-file, compatible with the root canal diameter, at the apex. To determine the root canal length using electronic methods, the teeth were included in alginate. The 30 teeth were measured with the three apex locators until achieving the apex foramen. During the measurement, the canals were inundated with 1% sodium hypochlorite. Statistical analysis was performed using Qui-square test ($p < 0.05$). **Results:** The Root ZX apex locator showed the higher accuracy (53.3%), with statistical difference in relation to iPex apex locator (33.3%) and YS-RZ-A apex locator (26.7%) ($p < 0.05$). Regarding the security limit of ± 1 mm, the Root ZX apex locator did not show statistical difference in comparison with iPex apex locator ($p > 0.05$), but both were statistically different in relation to YS-RZ-A apex locator ($p < 0.05$). **Conclusion:** The results showed that all the studied apex locators were efficient in determining the root canal length in tooth with incomplete apex, considering the tolerance of ± 1 mm. The Root ZX apex locator showed the highest accuracy with 100% of agreement.

Introduction

One of the first phases of endodontic treatment is to determine the working length (WL) which delimitates the instrumentation during chemical-mechanical preparation. By accurately determining this measurement, unpleasant consequences are avoided, among them: formation of steps on root canal walls, improper instrumentation and obturation, root perforation, and symptomatic post-operative period [8].

Studies similar to that of Kuttler [19] indicated the junction of dentin and cementum canal as landmark to limit endodontic treatment, an area so-called dentin-cementum canal (DCC). Notwithstanding, DCC limit does not precisely locate the apical foramen [7].

Many methods have been proposed to determine the working length of root canal from the patient's response to the pain provoked by surpassing the instrument through the apex foramen to the use of either conventional or digital radiographs [21].

The radiographic method is the technique most employed in working length determination, and some factors such as angulations, technical variables, interference of anatomic structures, and professional's interpretation may lead to errors [12]. Aiming to help the dentists in determining the apical limits, some devices have been developed to establish the canal length [3].

In 1918, Custer firstly conducted studies to determine root canal working length through electrical current, but only in 1942, Suzuki continued the studies and exposed a device measuring the electrical resistance between the periodontal ligament and oral mucosa. This study enabled the development of the first apical locator by Sunada, in 1962 [22].

With the appearance of electronic apex locators (EAL), an auxiliary tool was available in the endodontic armamentarium aiming at the correct odontometry [12]. The search for the reliability of these devices was determinant to develop the third-generation locators [3].

The main advantage of third-generation apical locators is that they detect the apical constriction, which is not possible through radiographs. Moreover, by using the electronic method in WL determination, the patient's exposure to radiation can be reduced because of the smaller number of radiographic shots. Other advantage is the shorter and lower-cost endodontic treatment by optimizing the working time of the dentist [18].

In teeth with incomplete apices the exact WL determination is indispensable for endodontic treatment success, either apexification or revascularization [23]. Notwithstanding, WL establishment in teeth with incomplete apices is still challenging for endodontic treatment because of the anatomic features of this area [17, 26]. Many authors have suggested that when root resorption is present, the use of apical locators

is reliable when certain degree of apical tapering exists [1, 11, 25].

In light of this, this study aimed to evaluate the *in vitro* accuracy of three apical locators – Root ZX (J. Morita Corp., Kyoto, Japan), iPex (NSK, Tokyo, Japan), and YS-RZ-A (Baistra, Henan, China) – in teeth with immature apices.

Material and methods

Thirty human single-rooted mandibular premolars, without caries, fracture and with 1-3 mm apical diameter, and at $\frac{3}{4}$ of root development with incomplete apices were used. All teeth had their extractions correctly indicated due to orthodontic reasons. All patients read and signed a Tooth Donation and Clarified Consent Forms. This study was submitted and approved by the Ethical Committee in Research of the University of Fortaleza (protocol no. #139/2009).

Crown accesses were performed with the aid of round diamond bur (KG Sorensen, Petrópolis, RJ, Brazil) at high speed and Endo Z drill (Dentsply Maillefer, Ballaigues, Switzerland). Irrigation was obtained through 1% sodium hypochlorite, and then, the canal was negotiated with the aid of size #15 K files. The teeth were numbered from 1 to 30 to allow the record of the WL obtained with each electrical apical locator.

Direct tooth measurement was carried out by placing a K file compatible with the root canal diameter, until the file was seen in the apex with the aid of an operating microscope at x40 magnification (DF Vasconcelos M9000, SP, Brazil) (figure 1).



Figure 1 - Direct odontometry measurement with the aid of operating microscope at x40 magnification

Next, the teeth were placed into glass flasks filled with alginate (Jeltrate-Dentsplay, Petrópolis, RJ, Brazil), so that the crown was visible thus avoiding that the alginate penetrated inside the canal. The labial clamp of EAL was inserted into the alginate. The electronic odontometry was obtained in each canal based on the methodology proposed by *et al.* [15]. All measurements were executed by a single operator, previously calibrated, to avoid discrepancies. The following apex locators were tested: Root ZX (J. Morita, Kyoto, Japan), iPex (NSK, Tokyo, Japan), and YS-RZ-A (Baistra, Henan, China). The reading of the apical foramen position was performed by introducing the file coupled to EAL inside root canal. The file was slowly moved towards apical direction until each device showed the correspondent sign of apical location (figure 2). Once the zero position was reached by the device, the file was disconnected and measured with the aid of a millimetric endodontic ruler. All canals were filled with 1% sodium hypochlorite during the measurements.



Figure 2 - Electronic apex locator

The data obtained from the three apex locators were classified in scores (accurate or inaccurate), paired in two-column tables, and analyzed by Chi-square test to compare the electronic with the direct measurements ($p < 0.05$).

Results

The electronic measurements of the 30 teeth are expressed in table I. A greater coincidence between the direct and electronic measurement was seen with Root ZX locator (53.3%), followed by iPex locator (33.3%), and YS-RZ-A locator, the less accurate (26.7%).

Table I - Accuracy of the electronic measurements in relation to direct measurements

Locators	Accurate		Inaccurate	
	Samples	%	Samples	%
Root ZX	16	53.3	14	46.7
iPex	10	33.3	20	66.7
YS-RZ-A	8	26.7	22	73.3

Taking into consideration the tolerance limit of ± 1 mm, Root ZX locator showed an accuracy of 100%, iPex locator of 83.3%, and YS-RZ-A locator of 73.3% (table II).

Table II - Accuracy of electronic measurements in relation to the direct measurements, considering differences smaller or equal to 1 mm

Locators	Tolerance limit ± 1.0 mm	
	Samples	%
Root ZX	30	100
iPex	25	83.3
YS-RZ-A	22	73.3

The analysis of the results obtained by the electronic measurements coinciding to the real measurements through Chi-square test showed that Root ZX locator had statistically higher results than did iPex and YS-RZ-A locators; iPex locator results were statistically higher than YR-RZ-A locator results.

Taking into consideration the tolerance limit of ± 1 mm, Root ZX locator results were statistically similar to iPex locator result; but these results were statistically significant different from those of YS-RZ-A locator.

Discussion

In this present study, by comparing the real measurements of the examined teeth with the measurements obtained by the apex locators, it could be observed that Root Zx locator exhibited 100% of accuracy at a tolerance limit of ± 1.0 mm. These findings are in agreement with the study conducted by Heidemann *et al.* [13], who also compared the real and electronic odontometry with an accuracy of 100%. Dandempally *et al.* [5] found an accuracy of 96.77% for Root Zx locator in primary teeth with root resorption.

Concerning to iPex locator, the results pointed out an accuracy of 83.3% inside the tolerance limit

of ± 1.0 mm. These results corroborate those found by Heidemann *et al.* [13], who reported an accuracy of 90%; and those found by Dandempally *et al.* [5], who reported an accuracy of 90.32%. It is noteworthy to mention that these authors analyzed teeth with complete apices.

As far as we are concerned, no studies on YS-RZ-A apex locator accuracy were found in the literature. In this present study, this apex locator showed an accuracy of 73.3% within the tolerance limit of ± 1.0 mm.

Root Zx and iPex locators did not exhibit statistically significant differences in the study conducted by Heidemann *et al.* [13], proving that iPex locators is as reliable as Root ZX locator, and corroborating the results of this present study.

Moore *et al.* [24] and Fouad *et al.* [9] affirmed that marked apical foramen openings may result in inaccurate measurements when EAL are used, highlighting the cases of incomplete rhizogenesis or pulp necrosis with periapical lesions involving bone and root resorptions. Frank and Torabinejad [10] verified that EAL ineffectiveness in determine WL in teeth with immature apices and that the file taper did not interfere in the readings of the devices. Likely, Herrera *et al.* [14] affirmed that the accuracy of Root ZX locator varied in function of the diameter of apical constriction. In these cases, the association of the radiograph and EAL is indicated to determine WL and provide a more accurate result [17].

Spironelli Ramos and Bramante [26] emphasized the difficulty in performing the electronic odontometry in teeth with immature apices by the lack of apical constriction. The use of alginate for the teeth insertion followed the suggestions of the studies of Czerw *et al.* [4], Baldi *et al.* [2], and Lipski *et al.* [20], which highlighted the advantage of this medium in *in vitro* studies on apical locators.

It is noteworthy to mention the importance that one single operator handled the EALs to obtained the results because according to Kielbassa *et al.* [16], two or more operators resulted in a significant difference in the WL measurements that disguised the real study result.

The results of this present study demonstrated the reliability of EALs in determining the working length in teeth with incomplete rhizogenesis. Although the results proved this effectiveness, most of the authors agree that EALs do not eliminate the need of taking a radiograph to determine the working length and root canal anatomy and morphology. Accordingly, the association of the radiograph and apical locator is the ideal method.

Conclusion

The results of this present study demonstrated that the analyzed apex locators were effective in determining accurately the working length of teeth with incomplete apices when a tolerance limit of ± 1.0 mm was taken into consideration. Root ZX apex locator was the most accurate with 100% of agreement.

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