

In vitro comparison of the efficiency of two electronic apex locators

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ABSTRACT

Introduction: Radiography has been widely used to determine working length in Endodontics, even though its limitations have been extensively recognized. In order to render the assessment of working length increasingly accurate, different electronic apex locators have been developed. **Objective:** The objective of this study is to compare *in vitro* the effectiveness of two electronic apex locators: Root ZX and Apex DSP. **Methods:** After coronary opening and preparation of the cervical and medium thirds of the root canal, a K-type file was inserted into the canal as far as the most cervical edge of the apical foramen. Subsequently, the teeth were

placed into containers and embedded in alginate together with the lip clip of the apex locator so as to determine tooth length. **Results:** Comparison between measurements showed an 87.5% accuracy rate for Root ZX vs. 77.5% for Apex DSP, suggesting that there is no statistically significant difference between the two apex locators. **Conclusions:** Electronic apex locators appear to be efficient and provide a reasonable alternative method to determine the correct working length.

Keywords: Odontometry. Root canal preparation. Endodontics.

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Introduction

Despite recent technological advances that allow Endodontics to become a highly successful practice, the apical limit of the working length in root canal treatment cannot be easily determined. This is because the working length is indirectly determined on the basis of clinically visible tooth crowns in their early stages, and the apical foramen which is not clinically visible.¹ As a result, a series of methods (from tactile sensitivity to radiography) and equipment have been developed to identify apical limits.

Radiography has become a widespread method for determining the working length. However, radiography is widely known for presenting its own limitations, namely: distortions produced by variation in vertical and horizontal angles, viewing of the mesiodistal plane only, and overlapping of anatomical structures.

Nevertheless, the main difficulty relates to the inability of radiographic imaging to determine variability in apical anatomy. This may inadvertently result in apical perforations, overinstrumentation, overfilling, postoperative pain, as well as deficient and incomplete instrumentation and obturation. Such events can evidently lead to unsuccessful endodontic therapy.

Proper endodontic treatment completion requires correct assessment of root canal length through preparation and obturation of root canals up to the vicinity of the canal-dentin-cement (CDC) limit. With the purpose of rendering this limit increasingly accurate, electronic apex locators, of which main features are speed, convenience and efficiency, have been developed and can now be used both for working length determination and for defining communication points between the root canal and the periodontium, fractures and resorption.

The applicability of these electronic devices has been thoroughly investigated. Moura et al² compared odontometry conducted by radiography and by two electronic apex locators and achieved similar results; thus concluding that the electronic method is indeed effective.

A similar method was employed by Marques and Marques³ to assess Justy II™ apex locator on 202 teeth of patients undergoing endodontic treatment, achieving 100% success proven radiographically. However, the authors basically regard the electronic method as an auxiliary tool in odontometry. They do not support the routine use of apex locators as they consider

odontometry radiography to be essential for viewing curvatures and furcations.

To demonstrate the clinical accuracy of apex locators Fouad and Reid⁴ compared the number of radiographs necessary to obtain adequate working length with and without an electronic estimate preceding odontometric radiography, noting that the prior use of Root ZX apex locator allowed for a reduction in the number of radiographs. Similar conclusions were reached by Sousa and Teixeira⁵ whose results show that the electronic technique was more economical and less time consuming than the radiographic method used to confirm the working length on 130 teeth.

When potential distortions resulting from a radiographic procedure are taken into account, it appears to be more effective to confirm the reliability of apex locators by comparing measurements obtained with locators to the actual size of the tooth.

An example of this procedure is found in the research by Coutinho and Siqueira¹ who observed that measurements on the Apit™ apex locator coincided with those obtained directly from 40 extracted teeth used in their study.

The purpose of this study was to compare the effectiveness and reliability of two electronic apex locators (Apex DSP and Root ZX) in correctly determining the root canal length of extracted teeth.

Material and Methods

A total of 40 human teeth were extracted by therapeutic recommendation of the Department of Surgery in the Dentistry undergraduate course at Paranaense University (Unipar). Only single-rooted, single-canal teeth were used with undamaged, straight roots and fully formed apices. Patients were informed about the procedures and signed an informed consent form approved by Paranaense University Institutional Review Board. The form was duly registered and approved by the Brazilian Research Ethics System (SISNEP: 0276.0.375.000-09) (file #16579).

After extraction, the teeth were kept in a sodium hypochlorite solution at 1% (Miyako, São Paulo, Brazil). Crown and pulp chamber were accessed with the aid of a spherical diamond bur #1014 (KG Sorensen, São Paulo, Brazil) under air/water refrigeration, abrading the tooth until it felt like an empty space, thus indicating that the pulp cavity had been reached. Subsequently, the diamond tip was replaced with a trunk cone-shape burs

without active edge #3082 (KG Sorensen, São Paulo, Brazil) to create the contour shape.

After removal of pulp chamber roof, orifice openers #1, #2 and #3 (Dentsply, Switzerland) were used with a 5-face pyramid-shaped active tip. Next, the cervical and medium thirds of the root canal were expanded with Gates-Glidden drills #03, #02 and #01 (Dentsply, Switzerland) used in descending order.

Once this phase was completed, a 10x magnifying glass (Motic, China) was used to explore the root canal with a Kerr-type file (Dentsply, Switzerland) and gauge compatible with the canal diameter. A K-type file was inserted until it could be viewed through the apical foramen, thus ensuring that the path was indeed unobstructed (Fig 1).

Thereafter, the K-type file was pulled back to the most cervical edge of the apical foramen (Fig 2) and grasped with a hemostat (S.S.White, Rio de Janeiro) placed on the highest apex of the dental crown. The distance between these two points was measured with the aid of a digital caliper (LEE Tools, China) (Fig 3) to obtain root canal length by direct method. Values were recorded in a form for later comparison.

Subsequently, teeth were placed in plastic containers and embedded in alginate (Jeltrade, Petrópolis, Brazil) along with the lip clip of the apex locator for assessment by electronic method using Root ZX (J. Morita, Japan) and Apex DSP (Septodont, France) apex locators (Fig 4).

The root canal was then rinsed with a 1% sodium hypochlorite solution to lubricate the passage, and a Kerr-type file of the same caliber was inserted by the direct method and connected to a clamp on the device while monitoring the proximity of the foramen until the apex locator reached the zero mark. Afterwards, the K-file was held with a hemostat using the same external reference to obtain the root canal length by direct method. The file was then pulled out from the canal and remeasured with a digital caliper.

The procedure was repeated on each tooth with both electronic apex locators.

The values obtained for each apex locator by direct method were statistically analyzed using Student's t-test with a 0.05 significance level to ascertain the reliability of the electronic method and assess the individual performance of each electronic apex locator.

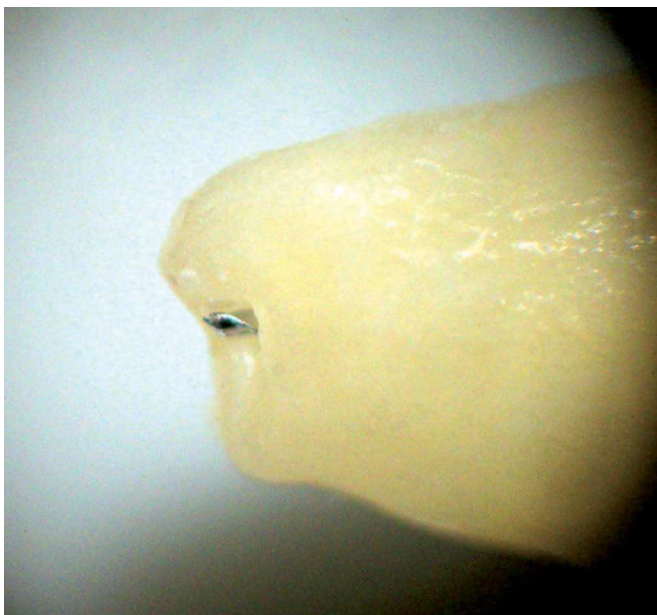


Figure 1. K-type file inserted into the root canal, surpassing the apical foramen.



Figure 2. K-type file inserted into the root canal and pulled back to the most cervical edge of the apical foramen.



Figure 3. K-type file removed from inside the root canal and measured using a digital caliper.



Figure 4. Teeth embedded in alginate with lip clip of apex locator.

Results

Result analysis indicates that Root ZX apex locator achieved 87.5% acceptable results for working length determination of the root canal, while Apex DSP locator achieved 77.5%.

A comparison between the values recorded by means of direct and the electronic method (Table 1) revealed that Root ZX apex locator presented coincident measures with the actual length of the root canal in 25 cases (62.5%), whereas in 10 cases (25%) the distance between the K-file tip and apical foramen showed a difference of approximately 0.5 mm. Of these, the K-file exceeded the measurement limit by direct method in only two cases, and in only five cases (12.5%) the difference was more than 1.0 mm short of the root apex. Apex DSP locator, on the other hand, showed coincident measurements with the actual length of the root canal in 14 cases (35%). The apex locator remained 0.5 mm short of the apical foramen in 17 cases (42.5%) and

Table 1. Distance from the file tip to the apical foramen.

Distance	Root ZX	Apex DSP
+0.5 mm	02	0
0.0 mm	25	14
-0.5 mm	08	17
-1.0 mm	05	09
Total	40	40

in nine cases (22.5%) the distance between the K-file and the root apex was greater than 1.0 mm.

Discussion

Accurate determination of tooth length (odontometry) is one of the most challenging phases of endodontic treatment, since the radiographic method is the technique most widely used to achieve working length. Nevertheless, this method has proven unequivocally ineffective to identify the CDC limit, which has been considered an ideal reference to assist in the preparation and obturation of root canal.⁶ Some studies indicate that in 75% of teeth in which the instrument is positioned next to the radiographic apex, it has in fact surpassed the apical foramen.² For this reason, in this study, we used extracted teeth, and by doing so it was possible to determine the actual root canal length by the direct method.

Since the last century, endodontists have sought alternatives to overcome the limitations of radiographs in determining root canal length.⁷ As stated by Serota et al,⁸ loss of 1 mm working length in cases where a periapical lesion is present increases the chance of endodontic treatment failure by 14%.

According to Soujanya et al,⁹ the requisites for an ideal method of working length determination are:

- » Quick location of apical constriction regardless of canal content;

- » Easy measurement, even when the relationship between apical constriction and radiographic apex is unusual;
- » Patient's fast and comfortable monitoring;
- » Patient's minimal radiation exposure;
- » Ease of use on special patients or patients with limited mouth opening;
- » Beneficial for pregnant patients;
- » Low cost.

To this end, in 1962, Sunada⁷ developed an apex locator that allows the passage of an electric current through the dental structure/periodontal ligament. This provided optimal results when the root canal was dry.

The electronic method aims to facilitate working length determination for instrumentation of the root canal. This method is easy, fast, efficient and accurate and contributes to the reduction of radiation exposure.³

According to Renner et al,¹⁰ apex locators act as capacitors that promote accumulation of electric charges in the periodontium and inside the tooth, while the dentin serves as an insulator making the electric current propagate in a different manner through the canal. This is also known as impedance.

The development of new apex locators, as described in the current literature, has led to highly encouraging results; thus overcoming the need for prior emptying and drying of the root canal.⁷ According to Brito-Júnior et al,¹¹ state-of-the-art impedance-frequency dependent type apex locators can now be used with 75%-100% efficiency and accuracy regardless of the solution applied, be it sodium hypochlorite, saline, xylene, chlorhexidine, EDTA, or in the presence of blood and pulp tissue. This occurs because apex locators perform the calculation of different impedance values within the canal by using two frequency signals.

The decision to use the apex locators tested in this study stems from the fact that both are last generation apex locators, namely, impedance-frequency

dependent devices. The Root ZX apex locator has been widely studied and, therefore, its results can be used as a benchmark for verification of the methodology applied. On the other hand, since the Apex DSP locator was launched recently there are only a few studies in literature describing its efficiency in measuring tooth length. Furthermore, its affordability has boosted its sales thanks to the use of LED lights to indicate the position of the instrument instead of a liquid crystal display.

Several studies^{6,12-16} report that an error margin or tolerance limit of more or less 0.5 mm relative to the actual tooth length is clinically acceptable. This is related to problems inherent in the apex locator operator. Therefore, in this experiment an 87.5% rate of acceptable values for the Root ZX was achieved and this is in agreement with similar studies which demonstrate a high level of accuracy in measurements with the Root ZX. Fouad and Reid⁴ achieved a 72% accuracy rate, Goldberg et al,¹⁷ 100%, Mearns and Steiman¹⁴ 83%, while Welk et al¹⁶ attained 90.7%.

For the Apex DSP locator a 77.5% rate of acceptable values was observed. Although the rate was lower than that achieved by the Root ZX, this is considered a highly satisfactory value. It should be noted yet again that the Apex DSP is scarcely described in the literature. Moshonov et al¹⁸ reported 84% of compatible measures, Lewiska et al¹⁹ reached 88.2% accuracy rate and Lipski et al²⁰ 90%.

Conclusions

Based on the methodology employed and the result analysis it is reasonable to conclude that:

- » Electronic apex locators afford a satisfactory alternative method to determine the correct working length.
- » Root ZX apex locator achieved a high success rate in determining the root canal length (87.5%) and performed better than Apex DSP locator (77.5%), but this difference was not statistically significant.

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