In vitro efficiency evaluation of an electronic apex locator in teeth with simulated root resorption

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ABSTRACT

Objective: This *in vitro* study evaluated the efficiency of electronic apex locator Novapex (Forum Technologies, Israel) in determining the working length, when used in different clinical situations, as in teeth with simulated external and internal resorption. **Methods:** Thirty single-rooted extracted human teeth (mandibular canines), with completely formed apices and with the same pattern of volume in the apical region, were used, using only its root portion. Initially, the length of each tooth was visually determined with a #10 K-file until the appearance of the apical foramen, subtracting 1 mm, setting the real work length measurement. The measure was taken again with the use of electronic apex locator apparatus and considered Novapex initial electronic length. Soon after, the wears were prepared to simulate the external and internal resorption. Measurements were taken again with the apex locator, and these were tabulated and analyzed. **Results and Conclusion:** The results showed that Novapex was highly accurate when considering 1-mm changes in the pre-determined measure. Through this study, we found that the apical locator Novapex was effective, showing to be a reliable method and no significant interference in his reading was detected when simulated external and internal resorption were present.

Keywords: Odontometry. Tooth resorption. Endodontics.

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Introduction

The success of endodontic therapy depends crucially on the correct execution of all stages, from diagnosis to the filling. These steps include determining the working length, the so-called tooth length that is a challenge to professional, depending on the anatomy of the apical region.[1] The accuracy in determining the work length plays an important role in reducing contamination and bacterial load in root canals. A non instrumented root canal, especially in cases of infected pulp and apical periodontitis leads to lower rates of success as compared with the complete preparation on the exact work legth.[2]

Several methods have been proposed for determining the length of the root canal, since the patient's response to pain caused by the passing of an instrument at the apical foramen to the use of conventional or digital radiographs.[3] With the advent of electronic apex locators (EALs) an additional feature was available in the endodontic arsenal to determine the correct odontometry.[1,2]

Several studies have shown that electronic odontometry is a fast and safe alternative for performing endodontic procedures. Kaufman et al[4] studied *in vitro* the odontometry precision of two EALs, Root ZX and Bingo 1020, comparing them with the radiographic method in 120 teeth. They found superior results of electronic devices, when compared with the radiographic method. Similar results on the efficiency of EALs has also been observed in several studies in endodontic literature.[5,6]

Despite the efficiency of these EALs, there are situations where may be some interference with the results of the measurements, caused by the influence of various factors, such as the presence of resorptions.[7] Therefore the aim of this study was to evaluate *in vitro* the efficiency of the apex locator Novapex (Forum Technologies, Israel) in teeth with non-communicant simulated external and internal root resorption.

Materials and Methods

To realize this *in vitro* study, were selected 30 single-rooted extracted human teeth that were obtained from the Tooth Bank of the Dentistry Faculty of State University of Rio de Janeiro. The selection criteria were teeth with complete root formation and apical foramen corresponding to a #10 K-file (Dentsply-Maillefer, Ballaigues). Exclusion criteria were teeth with obliterated root canal or with cracks.

The teeth were numbered and divided into four groups: Five teeth belonging to the positive control group (where was simulated a communication channel with the root resorption), 5 teeth belonging to the negative control (healthy crowns and roots), 10 teeth belonging to the group in which an external resorption was simulated and 10 teeth belonging to a group where was simulated an internal resorption. In the preparation of the teeth, coronal portion was removed leaving only the root portion.

The working length (WL) was determined 1 mm short of the foramen. To control the WL, the examiner performed the visual measurements with a #10 K-file until it left the apical foramen and then 1 mm was subtracted. The values were tabulated for comparison with the lengths obtained by the electronic method.

Prior to completion of perforations teeth length was obtained by the electronic method. This measurement was based on the methodology described by several authors.[6,8] The sample was fixed in plastic containers containing 0.9% saline solution, and the root was fixed with a wax layer, leaving a space for placing the labial clip in contact with the saline solution. Measurements were carried out using the EAL Novapex. A #10 K-file, was coupled to handle the device and during its insertion into the canal, the measurements were monitored on the device display, until the instrument reached the "APEX" mark. At this time, cursors were set on the coronal surface and measurements taken with the endodontic ruler (Dentsply-Maillefer, Baillagues, Switzerland). Measurements were recorded and considered as initial electronic length (IEL). The canals were irrigated with 0.9% saline during the measurements.

After this verification, root resorptions were performed. To create the external root resorption, a lateral wear was made, located at 5 mm to the apex, in the mesial wall, with the aid of a #4 low speed drill. To make the internal root resorption, we used a #4 low speed drill to penetrate the interior of the conduct to a depth of 8 mm from the root coronal surface.

After resorption prepare, a new measurement was made with the EAL Novapex, using the same method as described above for determining the IEL. Measurements were recorded and considered final electronic length (FEL).

Results

Measures of working length (WL), initial electronic length (IEL) and final electronic length (FEL) are shown in Tables 1 and 2.

Data recorded in mm were subjected to statistical analysis and the analysis of variance (ANOVA) showed no statistically significant difference ($p>0.05$) between measurements before performing resorption and after completion of resorption.

Table 3 presents in absolute and percentage values, the cases in which were verified the accuracy of electronic root measures in relation to real measurements, considering differences of 0.5 and 1.0 mm. The five teeth considered the negative control group, maintained their measurements within normal parameters, without presenting any interference. The positive control teeth showed changes in the electronic measurement.

Discussion

Much emphasis has been given to the odontometry stage, which aims to establish the apical limit of instrumentation and filling of the root canal system. The apex locators are auxiliary electronic devices of great importance in endodontics. These devices have been developed and have undergone changes in its operating principle over the years, to become more reliable and accurate during the tooth length.

Electronic odontometry has some advantages over the radiographic tooth length as possible to reduce the radiation dose during endodontic therapy[9] and the possibility of locating the apical constriction and the radiographic apex.[10] Is therefore a more reliable method, since the radiographic image distortion often difficult obtaining the correct working length.[11]

Despite the great efficiency of EALs, there are some situations, such as the presence of resorption or root fractures, which may cause some interference in the reading of these devices, affecting the determination of the working length.[7] The *in vitro* accuracy of four apex locators, Propex (Dentsply Maillefer, Ballaigues, Switzerland), Novapex (Forum Technologies, Israel), Root ZX (J. Morita Corp., Kyoto, Japan) and Elements Apex Locator (SybronEndo, Orange, CA) was tested on teeth with horizontal simulated fracture. It was concluded that all locators were able to determine the working length without showing any significant difference. But the EAL Novapex showed higher accuracy when compared to the Root ZX EAL.[12]

Although *in vitro* studies to investigate the accuracy of EALs are problematic due the absence of periodontal ligament, the EALs operate by electricity principles and when extracted teeth used in *in vitro* models are immersed in media with electrical resistance similar to

Table 1. Values of Working Length (WL), Initial Electronic Length (IEL) and Final Electronic Length (FEL) in the teeth with internal resorption (IR).

Tooth number	WL (mm)	IEL (mm)	FEL (mm)
1	18	18	17.5
2	17	17	17
3	17	17	17
4	20	20	19.5
5	17.5	17.5	17.5
6	18	18	18
7	14	14	14
8	16.5	16.5	16.5
9	17	17	17
10	16	16	16

Table 2. Values of the Working Length (WL), Initial Electronic Length (IEL) and Final Electronic Length (FEL) in the teeth with external resorption (ER).

Tooth number	WL (mm)	IEL (mm)	FEL (mm)
11	19	19	19
12	15	14.5	15
13	19	19	19
14	17	17	18
15	17	16	16
16	14	14	14
17	16	16	15.5
18	17	17	17
19	19	19	19
20	18	18.5	18

Table 3. Accuracy of electronic measures in relation to real measures, considering averages smaller than 0.5 mm.

Difference <0.5 mm				Difference <1 mm			
IR		ER		IR		ER	
n=10	100%	n=7	90%	n=10	100%	n=10	100%

the periodontal ligament may provides valuable information to test the correct operation of EALs.[13] Models of alginate were used accurately in several studies.[14,15,16] Another model using 0.9% saline solution and a plastic container was used successfully in several studies.[17,18] The saline solution is an excellent way to establish sufficient electrical circuit for the correct operation of the EALs, due to property impedance similar to periodontal ligament.[18] In this study the method using saline 0.9% was employed.

Similar study in which was detected the influence of non-interacting external resorption, showed no interference with the proper determination of working length using a EAL.[7] In the present study was evaluated the possible interference of external and internal root resorption, non-communicating, in the reading of the EAL Novapex. Results showed a 100% accuracy in the determination of tooth length in both cases of external and internal resorption, when the tolerance was 1 mm. When the used criteria was 0.5 mm of tolerance, in just one element with external resorption was not possible to locate the correct length. However, the tolerance of 1 mm is seen as clinically acceptable for several authors,[19,20] showing no major problems in identifying the correct length of the root canal resorption in cases of non-communicating external and internal resorptions.

Also in this work, the five teeth considered the positive control group, where there was communication with the saline solution, showed the most discrepant between 4 to 5 mm of difference, because the device was able to signal communication with the external environment, indicating that apex locators can be helpful in the diagnosis of perforation and possible communications between the external environment and canal.[16]

Therefore, according to the methodology employed in this study can be concluded that the electronic apex locator Novapex proved an efficient aid in determining the working length of root canals, even in different clinical situations, as in cases of external and internal resorption where there was no communication with the root canal, can still be used as aids in diagnosis of communicating root perforations.

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