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ORIGINAL ARTICLE

The Evaluation of Three Electronic Apex Locators in Teeth with Simulated Horizontal Oblique Root Fractures

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ABSTRACT

Aim: The accuracy of three electronic apex locators (EALs) to locate the apical limit in teeth with simulated horizontal oblique root fractures was investigated.

Material and methods: A horizontal oblique incomplete root fracture was simulated on 30 freshly extracted maxillary anterior teeth by means of a notch made on the vestibular root plane 8 mm from the anatomic apex. The EALs investigated were the ProPex II (Dentsply Maillefer, Ballaigues, Switzerland), the Mini Apex Locator (Sybron Endo, Orange CA), and the Dentaport ZX (J. Morita Corp, Kyoto, Japan). The electronic measurements were compared with the real "working length."

Results: The accuracy obtained was Dentaport ZX in 66.66% (n=20), the Mini Apex Locator in 63.33% (n=4) and the Propex II in 53.34% (n=4). The analysis of variance and chi-square test showed no statistical significant differences between Propex and Dentaport ZX EALs (Elecronic Apex Locators) at 0.5 mm and 1.0 mm tolerance levels. These results suggest that electronic apex locators can effectively and reproducibly detect oblique root fractures.

Conclusion: Although Propex II apex locator was not able to determine the working length accurately, but Dentaport ZX and Mini Apex Locator were able to determine the working length within acceptable range.

Keywords: Apical limit, electronic apex locators, horizontal oblique root fracture

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INTRODUCTION

The determination of an accurate working length is one of the most critical steps of endodontic therapy (1). The most common methods are radiographic methods, digital tactile sense, and electronic methods. Apical periodontal sensitivity and paper point measurements have also been used (2). However, neither tactile perception nor radiographs provide accurate measurements of canal length (3-5). Accuracy of radiographs is governed by various factors such as tooth inclination, position of the x-ray media, angulations of the x-ray tube, and superimposition of anatomical structures among others (6). Custer (7) investigated in 1918 the possibility to determine the position of the physiological foramen by means of an electric method,

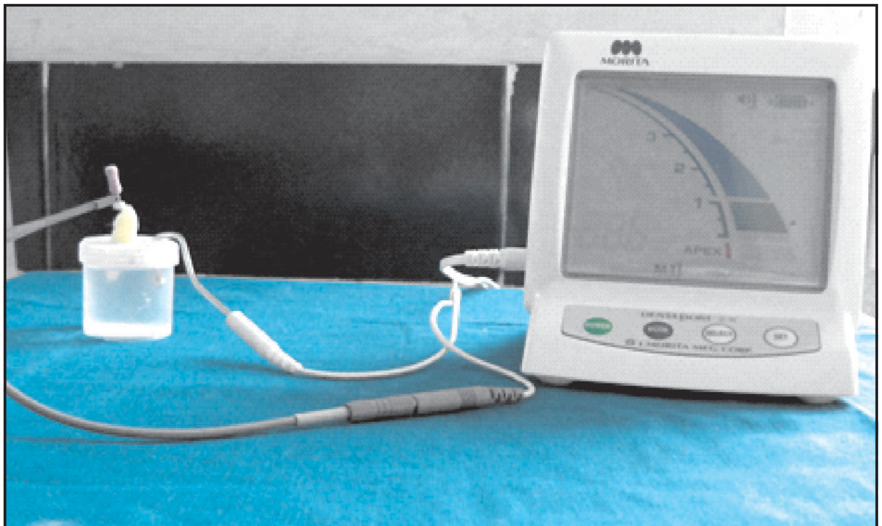

***Figure 1:** Set up of Test Apparatus*

which was definitively proven by Sunada (8). Electronic apex locator (EAL) devices, have been used to detect root fractures in some previous studies (9, 10). The principle behind is, that they should detect root fracture that reaches the pulpal chamber as an "apex" from the beginning of the periodontal connection at the fracture site (9). The coronal segment of the pulp of teeth with fractured roots will become non-vital with time but the apical segment remains vital (11); thus, the implementation of endodontic therapy up to the fracture line is recommended, leaving the apical root canal segment untreated (11). The fracture plane is usually beveled buccopalatally, making its interpretation on radiographs difficult (12). The aim of this investigation was to evaluate the ability of three frequency-based electronic apex locators to determine, in vitro, the coronal location of a 65° simulated horizontal root fracture.

MATERIALS AND METHOD

Twenty freshly extracted human maxillary anterior teeth were selected for this study. After extraction, teeth were cleaned with a #15 scalpel (Henry Schein Inc, Melville, NY), submerged in NaOCl (Merck Specialities, Mumbai, India) 5% for 15 minutes, and rinsed in a continuous water bath for 15 minutes. This was repeated twice to completely eliminate any root surface impurities. The root canal morphology was estimated before any investigation procedure by means of radiographs made in a buccolingual and mesiodistal plane. The teeth were consecutively numbered for identification purposes during all procedures. The access cavities were prepared with a round diamond bur 801 012 FG (Meissinger, Düsseldorf, Germany), and the access cavity walls were finished with EndoZ burs (Dentsply Maillefer, Ballaigues, Switzerland) under constant water cooling. The patency of the root canals was verified by means of a K-type file #15 (Dentsply Maillefer) before the root canal access enlargement, which was made with a Largo bur #1(Dentsply Maillefer) and irrigated with a 2.5% NaOCl (Merck Specialities) solution. A horizontal incomplete root fracture was simulated afterward through the preparation of an oblique notch on the buccal root surface with an approximately (65° ±5°) angulations with respect to the tooth axis by means of a 0.2-mm diamond disk (Horico, Berlin, Germany) at low speed and under constant water coolant. The notch was made 8mm from the anatomic apex of the root completely exposing the root canal.

A remnant of hard tissue was left on the palatal side of the root, thus avoiding complete separation of the apical root segment. The real "working length" (RWL) was determined after a thin spatula was placed into the root fracture plane on the coronal root segment, and a #25 K-type file (Dentsply Maillefer) was introduced until a firm contact with the spatula was made. The RWLs to the fracture plane or new apex were then recorded. The roots of the teeth were introduced up to the cementoenamel limit into a recipient containing a saline solution. The roots of the teeth and labial clip of the EALs were introduced through two perforations made in the lid of the recipient and fixed (Fig. 1). The root canals were irrigated with a saline solution, and the pulp chambers were dried with a cotton pellet. The "working length" electronic measurement of the roots was made from an incisal reference point to the root fracture plane with three different EALs: the ProPex (Dentsply Maillefer, Ballaigues, Switzerland), the Mini Apex Locator (Sybron Endo, Orange CA), and the Dentaport ZX (J. Morita Corp, Kyoto, Japan). The employment of the EALs was made according to the manufacturer's recommendation, and the electronic working length was determined when 0.5 could be read in the light-emitting diode displays of the EALs. Each root canal was measured with a K-type file (Dentsply Maillefer, Ballaigues, Switzerland) size that could be fitted at the fracture plane of the coronal root segment. The same instrument determined for each root canal was used with all EALs. The same operator made all measurements. The resulting data were recorded, and the results obtained were compared with the real length, allowing a tolerance of 0.5 and 1.0 mm. Measurements obtained and that were not within these limits were considered as unacceptable. The differences between the EALs were analyzed with an analysis of variance. The measurements recorded with each EAL at the 0.5-mm and 1.0-mm tolerance levels were analyzed with the chi-square test ($p=0.05$), and 95% confidence intervals were calculated with the binomial distribution.

RESULTS

A total of 90 "working length" electronic measurements were made, 30 with each EAL. The results obtained are summarized in Table 1 (0.5-mm and 1.0-mm tolerance). Acceptable results at a 0.5-mm tolerance (Table 1) were obtained with the Dentaport ZX in 66.66% (n=20), the Mini Apex Locator in 63.33% (n=14) and the Propex II in 53.34% (n=4).

Table 1: Mean difference in 3 groups

Anova		Sum of squares	df	Mean Square	F	Sig.
DENTAPORT-ZX	Difference between groups	133.827	13	10.294	26.359	.000
	Within Groups	6.639	17	.391		
	Total	**140.467**	**30**			
MINI APEX LOCATOR	Difference between groups	100.710	13	7.747	5.977	.000
	Within Groups	22.032	17	1.296		
	Total	**122. 742**	**30**			
PROPEX-II	Difference between groups	68.638	13	5.280	1.900	.107
	Within Groups	47.229	17	2.778		
	Total	**115.867**	**30**			

DISCUSSION

The presence of root fractures as a consequence of dental trauma in permanent teeth has been observed with an almost 7% frequency (13). Such fractures cannot always be diagnosed by means of a radiograph within the first hours after the dental trauma incident; thus, the necessity of periodical clinical and radiographic controls becomes necessary. Furthermore, the location of the fracture plane with respect to the root axis is also radiologically difficult. Andreasen and Andreasen (13) have recommended the use of three different radiographs with different angulations to facilitate the diagnosis of a horizontal root fracture. It has been found that the coronal root segment can lose vitality while the apical segment remains vital. Under such circumstances, different (11,14) authors have suggested to perform an endodontic treatment only on the coronal root canal segment and consider the fracture plane as the limit of the working length. Yet, an accurate localization of the cleaning, shaping, and filling limit in such cases is often a difficult procedure for the operator because the fracture plane is usually beveled buccopalatally, making its interpretation on radiographs difficult. Several investigators (4, 15-18) have shown that EALs are reliable to determine the working length. Thus, it was our aim to confirm the reliability of three different EALs in simulated clinical conditions in which an oblique horizontal root fracture is present and therefore may not represent in vivo conditions. In the present study, horizontal fractures were simulated at the 8th mm of the roots. The simulated fractures were made by cutting the roots with a 0.2-mm disk by one operator so the fragment separation distance was equal or more than 0.2 mm. Fragment separation distance was usually an important factor in diagnosing and treating fractures. In clinical conditions, incomplete fractures might have various approximation distances. In the present study, the fractures were simulated by using a previously used method (12). Azabal *et al.* conducted a similar study in which only one device (Justy II) was investigated (9). These authors reported a 93.5% and 100% of accurate measurements when allowing a 0.5-mm and 1.0-mm tolerance, respectively. T Goldberg *et al* (12) conducted a similar study in which the EALs investigated were the ProPex (Dentsply Maillefer, Ballaigues, Switzerland), the NovApex (Forum Technologies, Rishon Le-Zion, Israel), the Root ZX (J. Morita Corp, Kyoto, Japan), and the Elements Apex Locator (SybronEndo, Orange CA). The accuracy obtained was of 80% (n =16) and 95% (n =19) with the ProPex, 70% (n =14) and 95% (n =19) with the NovApex, 60% (n = 12) and 90% (n= 18) with the Root ZX, and 60% (n =12) and 85% (n =17) with the Elements Apex Locator when tolerances of 0.5-mm and 1.0-mm tolerance were, respectively, allowed. These results are not in agreement with the ones obtained in this investigation in which the results with the different EALs were between 53.34% and 66.66% for tolerances of 0.5 and 1.0 mm. In this investigation, contrary to the report of Azabal *et al.* (9), the crowns of the teeth were not separated, thus keeping the research variables closer to an in vivo situation. Furthermore, the determination of the real working length was made when the measuring instrument reached a firm contact with the spatula at the fracture plane, instead of a 2.5x visual magnification, which may have allowed no margin of error. Shabahang *et al.* suggested that a 1.0-mm tolerance can be considered clinically acceptable (16). We are of the opinion that this tolerance margin should also be considered acceptable, especially when the determination of the apical limit becomes more difficult because of the fracture plane inclination with respect to the root axis. The 65° inclination of the fracture plane simulated in this investigation was considered as research variable in an effort to simulate clinically difficulties with respect to the radiograph interpretation.

CONCLUSION

Although Propex II apex locator was not able to determine the working length accurately, but Dentaport ZX and Mini Apex Locator were able to determine the working length within acceptable range. These results suggest that electronic apex locators can effectively and reproducibly detect oblique root fractures.

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