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Evaluation of accuracy of two electronic apex locators Viz Propex-II and Elements Apex Locator: An In-Vitro Study

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ABSTRACT:

Background: To compare the accuracy of two commonly used multiple frequency electronic apex locators Viz.Propex-II(Dentsply, Maillefer) and Elements apex locator(Sybron dental specialities)

Method: Electronic working length determination was carried out in 22 single rooted extracted teeth using an In-vitro model(Gelatin conducting medium). Teeth were decoronated and the root canals coronally flared. Actual canal lengths were then determined by inserting a #10 k-file until the tip was visualized (12.8X magnification) just within the apical foramina and randomly tested with each electronic apex locator (EAL) to determine the electronic canal length. The Actual length was subtracted from the electronically determined distance. The measurements exceeding the Actual length were recorded as positive (long) and the measurements (short) of the AL were recorded as negative.

Results: The Mean differences between electronic and actual lengths - 0.2 mm and 0.43 mm for Elements apex locator and Propex II respectively. Unpaired student T-test showed no significant difference among EALs (P=0.005). The proportion of electronic canal length measurements falling within ±0.5 mm of the actual canal lengths for the EALs was as follows: 86.36% for the Elements apex locator and 81.82% for the Propex II.

Conclusion: Elements apex locator was more accurate at locating the apical foramen compared with the Propex II

Key words: ***Electronic Apex Locator, Elements, Propex II***

INTRODUCTION:

Success or failure of endodontic treatment depends, among other parameters, on an accurate determination of the working length. Electronic apex locators (EALs) are a routinely used procedure in endodontic practice ; yet their accuracy has been reported to vary from 35%[1] to 100%.[2] The operating systems of the EALs (frequency or impedance quotient) and different investigative methodologies explain the higher accuracy obtained with the current generation of devices.

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At the apical foramen, the cementodentinal junction (CDJ) or minor constriction is the landmark that anatomically and histologically determines where the pulp ends and the periodontal ligament begins. Root canal preparation techniques attempt to use this natural barrier as the endpoint for canal preparation. However, Lee et al.[3] Found that almost 50% of teeth evaluated had no distinguishable CDJ. Therefore, the CDJ should be thought of as a histologic and not a morphologic landmark.

Traditional methods for establishing working length include the use of radiography anatomical averages and knowledge of anatomy, tactile

sensation and moisture on a paper point. All of these methods have limitations. Radiographs are subjected to distortion and magnification and are technique sensitive in both their exposure and interpretation. Furthermore, a radiograph provides a two-dimensional image of a three-dimensional structure which lacks of a real representation.[4] Even amongst experienced clinicians the use of anatomical averages, knowledge of anatomy and tactile sensation has been shown unreliable and subjected to marked intra-subject differences. Therefore, these methods for root canal measurement do not allow precise localization of apical constriction and CDJ and do not guarantee that instrumentation beyond the apical foramen will be avoided.[5]

The development of electronic apex locators (EALs) has helped make the assessment of working length more accurate and predictable[4,5] and used with appropriate radiographs, it allows for much greater accuracy of working length determination.[4,6]

Electronic apex location began in 1942 with studies by Suzuki.[7] He discovered that a constant electrical resistance of approximately 6.5 kU existed between the periodontium and oral mucous membrane in vivo. In 1962, Sunada[8] formulated his principle of "biological characteristic theory," stating that electrical resistance values between the periodontal ligament and the oral mucosa can be determined by electronic means.

Modern theories suggested, however, that the phenomenon could be mainly electrophysical in nature.[9] Inoue[10] developed a sonic readout system by using a transistor equalizer-amplifier feedback circuit and low frequency oscillation for root canal length measurement. Ushiyama[10] described the gradient impedance method to determine working length in the presence of electrolytes.

The main shortcoming of early first and second generation EALs (erroneous readings with electrolytes) was overcome by Kobayashi et al.[11] with the introduction of the ratio method and the subsequent development of the self-calibrating Root ZX (J. Morita Corp., Tokyo, Japan).

As many as four generations of electronic apex locators (EALs) have been developed since their inception.[12] The Elements Diagnostic Unit and Apex Locator (Sybron Endo, Sybron Dental, Anaheim, CA, USA) is claimed to be a fourth generation apex locator. The device does not process the impedance information as a mathematical algorithm, but instead takes the resistance and capacitance measurements separately and compares them with a database to determine the distance to the apex of the root canal. It uses a composite waveform of two signals, 0.5 and 4 kHz, compared with the Root ZX at 0.4 and 8 kHz. The signals go through a digital-to-analogue converter to be converted into an analogue signal, which then goes through amplification and then to the patient circuit model which is assumed to be a resistor and capacitor in parallel. The feedback signal waveforms are then fed into a noise reduction circuit.[13] The manufacturer claims that directly measuring resistance and capacitance eliminates the potential of error introduced by the possibility of reading the same impedance provided by the different combination of resistance and capacitance if they are not measured independently. A recent investigation has demonstrated a great level of accuracy of this EAL in usage in vivo.[14]

ProPex II (Dentsply Maillefer, Ballaigues, Switzerland) is a multi-frequency based apex locator which is based on the same principles of the other modern devices which use multiple frequencies to determine root canal length. The manufacturer does not specify any other technical characteristics and no studies are present in current literature on the in vitro or in vivo accuracy of this EAL. The purpose of this study was to compare the accuracy of the Elements apex locator and the Propex II.

Materials and Methods:

Twenty two single-rooted extracted teeth were obtained and gross debris was removed from the root surfaces with a soak in 3% NaOCl (Vensons, Banglore,India). The root surface and apical portion of each tooth were examined for the absence of fractures and the presence of a mature apex under a dental operating microscope (Seiler Precision Microscope,St Louis) at 12.8 x magnification. All samples met these inclusion criteria. The crown of

each tooth was then sectioned at the cementoenamel junction with a diamond disk to provide unrestricted access to the canal space and to provide a constant reference point for all measurements. The coronal portion of each canal was flared by using sequential Gates Glidden drills #3, #2 and #1 in a crown-down fashion. Irrigation was then performed with 5.25% NaOCl followed by sterile saline to remove gross debris from the canal space.

A #10 K-File (Mani Inc.,Tochigi, Japan) was then used to verify patency of the canal space and the apical foramen under the dental operating microscope.

Teeth were numbered 1 to 22 and randomly selected for measurement using a #10 K-File (Mani) with double stoppers. Double stoppers were used to decrease the chance of stopper movement during measurements. The file was advanced until the tip of the file could be visualized just within the apical foramen under 12.8x magnification using the dental operating microscope. This length was then measured with Travelling microscope(ELFO Scientific apparatus,India) to within one hundredth of a millimetre and recorded as the actual length. Files and stoppers were used for only five measurements and discarded. The teeth were placed in a conducting medium of gelatin (Nitta Gelatin Ltd.,Cochin). Each EAL was used according to manufacturers' recommendations for detecting the major apical foramen. For the Elements apex locator, this was the solid "apex" bar appearing on the EAL screen. For propex II, when apex is reached a solid tone is emitted along with the visual file tracking down to the apex.Differences between the electronic and actual canal lengths were calculated. Positive values indicated measurements that were long of the apical foramen, negative values indicated measurements that were short of the apical foramen, and 0.0 values were considered coinciding measurements. Unpaired student-T test was then applied to analyze the data with the significance level set at 5%.

Results:

Mean differences between the electronic and actual lengths were 0.2 and 0.43 for Elements apex locator and Propex II respectively.No significant difference was noted between the Elements apex locator and the PropexII (Table 1).When a clinical acceptability limit of ±0.5 was kept the actual within-range proportions were as follows: 86.36 for the Elements apex locator and 81.82% for the Propex II, Table 2 shows where sample measurements were short, long, or within this range.

Discussion:

Root canal preparation techniques attempt to use minor constriction as the endpoint for canal preparation. Root fillings terminating at the apical constriction provide optimal healing conditions, reducing tissue destruction, persisting inflammatory responses and foreign body reactions.[15,16,17]

Variation in root-end morphology as studied in the works of Kuttler in 1955, Green[19] in 1956, and Dummer et al.[19] in 1984 showed that radiographic interpretation alone cannot be depended on to establish the working length and that electronic determination is necessary.

Advantages of electronic apex location includes

- More accurate,easy and fast
- Helpful in detecting perforations
- Useful adjunct in pregnant, handicapped patients or patients with extreme gag reflex.
- Useful in situations in which Superimposition of anatomic structures such as the zygomatic arch or adjacent roots occur over the roots of teeth requiring endodontic therapy,[20] and,
- Reduction of exposure to radiation.

Drawbacks of electronic apex location includes:

- Intact vital tissue, inflammatory exudate and blood — can conduct electric current and give inaccurate readings
- Lack of patency, accumulation of dentine debris and calcifications - can affect accurate WL determination
- Potential to cause alteration in cardiac pacemaker function but newer apex locators have overcome this disadvantage also.[21]

Raphael R. Garofalo et al[22] studied the effect of five electronic apex locators on cardiac pacemaker function. He stated that four of them did not cause any inhibition or interference with normal pace

maker function. However to be safe, electronic gadgets should be avoided in patients with cardiac pace makers and if usage is deemed necessary a cardiologist's consent is mandatory.

There has been controversy as to whether EALs are able to determine the minor constriction or the major foramen. Mayeda et al.[23] concluded that EALs are only capable of detecting the major foramen. Ounsi and Naaman[24] confirmed this point in 1999, concluding that "The Root ZX is not capable of detecting the '0.5 mm from the foramen' position and thus, should only be used to detect the foramen (major diameter)."

Lee et al.[3] found that file tips ended in the area of the major foramen regardless of the CDJ presence and that the major foramen is a better level to test for EAL accuracy. Recently, Herrera et al.[25] found that the diameter of the files used to determine working lengths with Root ZX had no significant effect until the apical widths were instrumented to a diameter of 1.02 mm. Hassanien et al.[26] recently found that "[The] CDJ and apical constriction are not the same point, the apical constriction was always found coronal to [the] CDJ,".This is not surprising, considering the findings of Ounsi and Naaman.[24] Therefore, the current study used the major foramen as the measuring point for all three EALs.

The relative stiffness of the gelatin medium prevented fluid movement inside the canal that is responsible of premature electronic readings registered with previous models.[27,28] In this way, it could be possible to overcome the limitations of the in vitro models.

Considered to be a useful guide for clinical acceptability, the ±0.5 mm range from actual canal length was also used to test accuracy in this study.[27] The large majority of EAL measurements were within the ±0.5-mm range for both electronic apex locators. The ELE had two measurements long of this range and only one measurement short of this range. The Propex II had one measurement long of this range and three measurements short of this range.

Concern over overextended preparations and subsequent compromised obturations has produced differing opinions as to how to use these EALs correctly. The manufacturers suggest determining the working length by using the EAL to determine the major foramen and subtracting approximately 0.5 mm.[29,30,31] Many practitioners believe this may still violate the minor constriction and suggest subtracting 1.0 mm from what is determined electronically as the major foramen. Using descriptive statistics, the present study suggests that subtracting only 0.5 mm would likely produce overextended preparations in 9.09 % of ELE and 4.5% of Propex II electronic measurements. It is ultimately the responsibility of the practitioner to determine how these devices are used.

Conclusion:

Under the conditions of this in vitro study, the Elements apex locator was the most accurate at locating the apical foramen compared with the Propex II Apex Locator. When using a clinical acceptability range of ±0.5 mm from actual canal lengths, the Elements apex locator also had the highest in-zone proportion of acceptable measurements at 86.36%.

References:

1. Welk AR, Baumgartner JC, Marshall JG. An in vivo comparison of two frequency based electronic apex locators. J Endod 2003;**29**:497-500.
2. Plotino G, Grande NM, Brigante L, Lesti B, Somma F. Ex vivo accuracy of three electronic apex locators: Root ZX, Elements Diagnostic Unit, Apex Locator and ProPex. Int Endod J 2006;**39**:408 -414.
3. Lee SJ, Nam KC, Kim YJ, et al. Clinical accuracy of a new apex locator with an automatic compensation circuit. J Endod 2002;**28**:706-709.
4. Pratten D, McDonald NJ. Comparison of radiographic and electronic working lengths. Journal of Endodontics 1996;**22**:173-176.
5. ElAyouti A, Weiger R, Lost C. The ability of root ZX apex locator to reduce the frequency of overestimated radiographic working length. Journal of Endodontics 2002 ;**28**: 116-119.
6. Hoer D, Attin T. The accuracy of electronic working length determination. International Endodontic Journal 2004;**3**:125-131.
7. Suzuki K. Experimental study on iontophoresis. Japanese J Stomatol 1942;**16**: 411-429.
8. Sunada I. New method for measuring the length of the root canal. J Dent Res 1962; **41**:375-387.

9. Ushiyama J. New principle and method for measuring the root canal length. Journal of Endodontics 1983; **9**: 97-104.
10. Inoue I. Dental 'stethoscope' measures root canal. Dental Survey 1972;**48**:38-39.
11. Kobayashi C, Okiji T, Kaqwashima N, Suda H, Sunada I. A basic study on the electronic root canal length measurement: Part 3. Newly designed electronic root canal length measuring device using division method. Japanese Journal of Conservative Dentistry 1991;**34**:1442-1448.
12. Guise G, Goodell G, Imamura G. In Vitro Comparison of Three Electronic Apex Locators. J Endod 2010;**36**:279-281.
13. Gordon MPJ, Chandler NP. Electronic apex locators. International Endodontic Journal 2004;**37**: 425-437.
14. Cunha D'Assunc¸a˜o FL, de Albuquerque DS, de Queiroz Ferreira LC. The ability of two apex locators to locate the apical foramen: an in vitro study. J Endo 2006;**32**:560-562.
15. Seltzer S, Soltanoff W, Sinai I, Goldenberg A, Bender IB. Biologic aspects of endodontics. Part III. Periapical tissue reactions to root canal instrumentation. Oral Surgery, Oral Medicine and Oral Pathology 1968; **26**: 534-46, 694-705.
16. Seltzer S, Soltanoff W, Sinai I, Smith J. Biologic aspects of endodontics. Part IV. Periapical tissue reactions to rootfilled teeth whose canals had been instrumented short of their apices. Oral Surgery, Oral Medicine and Oral Pathology 1969;**28**:724-738.
17. Ricucci D, Langeland K Apical limit of root canal instrumentation and obturation, Part II: A histological study. International Endodontic Journal 1998; **31**: 394-409.
18. Green D. A stereomicroscopic study of the root apices of 400 maxillary and mandibular anterior teeth. Oral Surg Oral Med Oral Pathol 1956;**9**:1224-1232.
19. Dummer PM, McGinn JH, Rees DG. The position and topography of the apical canal constriction and apical constriction. Int Endod J 1984;**17**:192-198.
20. Tamse A, Kaffe I, Fishel D. Zygomatic arch interference with correct radiographic diagnosis in maxillary molar endodontics. Oral Surg Oral Med Oral Pathol 1980;**50**:563-566.
21. Beach et al "Effect of electronic apex locators on cardiac pacemakers function' Journal of endodontics 1996;**22(4)**:182-184
22. Raphael R.G., Elias N.E., Samuel O.D. and Sergio K."Effect of electronic apex locators on cardiac pace maker function" Journal of endodontics 2002; **28(12)**: 831-833
23. Mayeda DL, Simon JH, Aimar DF, et al. In vivo measurement accuracy in vital and necrotic canals with the Endex apex locator. J Endod 1993; **19**:545-548.
24. Ounsi HF, Naaman A. In vitro evaluation of the reliability of the Root ZX electronic apex locator. Int Endod J 1999;**32**:120-123.
25. Herrera M, A´ balos C, Planas AJ, et al. Influence of apical constriction diameter on Root ZX apex locator precision. J Endod 2007;**33**:995-998.
26. Hassanien EE, Hashem A, Chalfin H. Histomorphometric study of the root apex of mandibular premolar teeth: an attempt to correlate working length measured with electronic and radiograph methods to various anatomic positions in the apical portion of the canal. J Endod 2008;**34**:408-412.
27. Fouad AF, Krell KV, McKendry DJ, Koorbusch GF, Olson RA. A clinical evaluation of five electronic root-canal length measuring instruments. Journal of Endodontics 1990;**16**:446-449.
28. Czerw RJ, Fulkerson MS, Donnelly JC. An in vitro test of a simplified model to demonstrate the operation of electronic root-canal measuring devices. Journal of Endodontics 1994;**20**:605-606.
29. Fouad AF, Krell KV, McKendry DJ, et al. Clinical evaluation of five electronic root canal length measuring instruments. J Endod 1990;**16**:446-449.
30. Ricard O, Roux D, Bourdeau L, et al. Clinical evaluation of the accuracy of the Evident RCM Mark II apex locator. J Endod 1991;**17**:567-569
31. Root ZX II. Operation Instructions, J. Morita Corp., Kyoto, Japan, 2005.
32. Precision Apex Locator, Operation Manual. Brasseler USA, Savannah, GA, 2006.
33. Elements Apex Locator, Instruction Guidelines, SybronEndo, Sybron Dental Specialties,Glendora, CA, 2006.

Table I. Mean Differences between Electronic and Actual Length Measurements

Group	N	Mean	Standard deviation
ELE	22	0.2027	1.9218
Propex II	22	0.4300	1.9380

ELE, Elements Apex Locator;

Positive values indicate means longer than the actual canal lengths. Negative values indicate means shorter than the actual canal lengths.

TABLE II. Sample Values Falling Short, Long, or within ± 0.5 mm from the Actual Canal Lengths

Group	< 0.5	+/- 0.5	>0.5
ELE	1	19	2
Propex II	3	18	1

ELE, Elements Apex Locator