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Original Study

Two distinct apex locators' accuracy in estimating the working length in teeth with roots which are curved: an in vitro investigation

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ABSTRACT

Aim
To determine how the tooth’s root canal curvature affects the apex locator's accuracy.

Materials and Methods
For the study, 20 human mandibular molars that had been extracted and whose mesial roots had a minimum 20-degree curvature were chosen. The teeth were mounted in alginate and then subjected to an accuracy test for locating each tooth's apex using the Root ZX and Propex Pixi apex locators.

Results
Working length determination done using Root ZX II showed more accurate length relative to the preoperative working length

Conclusion
Consequently, Root ZX (J MORITA, Japan) provided more precise results than Propex Pixi (Dentsply). has a difference that is significant at 0.05.

***Keywords:** Working length, Electronic apex locators, Canal curvature, Consistency, Root ZX II, Propex Pixi.*

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INTRODUCTION

The term "Working Length" (WL) is used to describe the distance between a coronal reference point and the location where canal preparation and obturation should end.[1] Apical perforation, overextension, and higher post-operative pain may occur because of length being too long, which would diminish the success rate. Accurately determining and maintaining WL is also important. The major constriction, which is 0.5 mm coronal to the apical foramen, is positioned 0.5-0.75 mm from the apical constriction.[2,3] Incomplete cleaning and underfilling caused by WL that is too short of the apical constriction might result in ongoing pain and peri-radicular infections.[4]

Working length is measured using radiographs, electronic apex locators, and the tactile perception of the operator. The radiographic approach is the one utilized for WL determination the most frequently. Because radiographs only provide a two-dimensional depiction of the three-dimensional object and might be interpreted differently by different doctors, this approach frequently produces inaccurate results.[5] The electronic apex finder was created in response to growing radiation exposure concerns (EAL). Radiographs are used to calculate the working length, which is measured 0.5mm–1.0mm below the radiographic apex of the tooth. However, it has been discovered that the radiography approach is linked to interpretation uncertainty, shortening or elongation, and a lack of three-dimensional representations.[6] In terms of precision and consistency, electronic apex locators are thought to be far more dependable and better than radiographic techniques. Electronic apex locators are not perfect, though.

Custer performed the first electrical working length measurement in 1918.[7] Suzuki created the first electronic apex locators in 1942.[8] The later devices were impedance-based, whereas this device was resistance-based. Electronic apex locators are not functioning when they read inconsistently or not at all. Studies on the variable performance of EALs are scarce. For verification, radiographs with electronic apex locators are advised. It is yet unclear why electronic apex locators are inaccurate. It is true that dentine and cementum, which are insulators to electric current, surround the root canal. The periodontal ligament, which is a conductor of electric current, is electrically coupled to conductive elements within the canal at the minor apical foramen. A resistor is made up of the canal's resistive components, such as dentine, tissue, and fluid, and its value is determined by its length, cross-sectional area, and resistivity. The resistance between the end of the instrument and the apical region of the canal lowers when an endodontic file is placed into the canal and gets close to the canal terminus because the effective length of the resistive material inside the canal shortens.[9]

Root ZX, a third generation EAL, employs two waveforms simultaneously: a high (8 kHz) and low (400 Hz) frequency waveform. The Root ZX's accuracy has been recorded to range from 64 to 100%, with 97% being the most frequent value. It is well established that several factors, including preflaring,[10] instrumentation stage,[11] apical constriction,[12] and irrigant type,[13,14] affect the accuracy of apex locators. It is frequent in clinical settings to see curved root canals, which may be another morphological aspect dictating how long they should be. Along with computing the root mean square (RMS) values of the electric signals, the fifth generation of EAL also makes use of numerous frequencies. The RMS is less impacted by electrical sounds than other physical constraints, such as phase of electrical signals or amplitude, that are employed by other EALs because it represents the energy of the electric impulses.

The Propex Pixi, an updated version of the recently created EAL Propex, is an illustration of a fifth generation EAL (Dentsply Maillefer). For determining the file tip location in relation to the root apex, the Propex Pixi and Root ZX II utilize signals at two diverse frequencies. Additionally, Propex Pixi uses a different technique than Root ZX II since it measures the RMS of the electric signal and uses that information for calculations. Due to these technological differences, a comparison of the Root ZX II's and the Propex Pixi's accuracy in determining

root canal working lengths is necessary. In this study, a third generation EAL (the Root ZX II) and a fifth generation EAL (the Propex Pixi) were used to examine the precision of root canal working length in 20 extracted teeth.

MATERIALS AND METHODS:

Criteria for selection of teeth:

20 extracted human mandibular molars with mesial roots that were at least 20 degrees curved were chosen for the investigation. Using schneider's method10, the degree of root canal curvature was determined. Until usage, teeth were kept in an H2O2 solution. The root surfaces were cleaned of filthy particles with a 10-minute soak in 6% sodium hypochlorite (NaOCl).

Method of collection of data:

Until usage, teeth were kept in an H2O2 solution. The root surfaces were cleaned of filthy particles with a 10-minute soak in 6% sodium hypochlorite (NaOCl PRIMEDENT). Using the SX files of ProTaper Rotary (Dentsply Maillefer, SWISS) devices, the coronal third was preflared. By inserting a No.15 file into the canal and observing it visually until the tip of the file emerged through the main apical foramen, the actual root canal length was calculated (naked eyes). The distance between the stopper and the tip of the file was measured using digital vernier calipers to the nearest 0.01 mm. The Actual Working Length was noted as being this (AWL). For embedding the teeth, newly mixed alginate was placed in a plastic container of roughly 7 x 14 cm. The canals were watered, and extra liquid was drained. Within the alginate, the lip clip was firmly fastened to the plastic container. When Root ZX reached the "Apex" reading, the file clip was attached to the file and it was inserted (J Morita Corp, Tokyo, Japan). As the electronic working length, this was chosen (EWL). Calculated was the difference between the AWL and EWL.

RESULTS:

Table1: Dictates mean and standard deviation of pre operative working length, Propex Pixi reading, Root ZX reading respectively. It is evident that Root ZX apex locators showed nearly equal results of preoperative working length than Propex Pixi apex locator.

Groups	**Mean ±Standard Deviation**	
	MB Canal	**ML Canal**
Pre-Operative working Length	18.10±1.17	18.57±1.27
Propex Pixi	17.07±1.28	17.37±1.35
Root ZX	18.08±1.47	18.50±1.36

Table 2: Hoc Tests

Groups	(P<0.05)	
	MB Canal	ML Canal
I vs II	.049*	.017*
II vs III	.047*	.028*
I vs III	1.000	1.00

*mean indicates there is significant difference at <0.05

Above table dictates,
I – Pre-operative
II – Propex Pixi
III – Root ZX -II

Results of this study dictates that the working length determination done using Root ZX II showed more accurate length relative to the preoperative working length i.e., preoperative working length is more or less equal to the readings of Root ZX.

DISCUSSION

In a study using a scanning electron microscope (SEM) to assess the accuracy of Root ZX EAL, it was discovered that cases with a normal apical foramen had much lower apex location errors than those with lateral foramen, where a severe curve of canal exists at the apical third. In one investigation, the WL of straight and curved canals were determined using the Raypex 5 apex locator and traditional radiography. The findings of this study revealed that for straight root canals, the percentage of electronic readings within 0.05 of AWL was 70%, and for curved root canals, it was 35%.[15] These results might support the hypothesis that curvature is a substantial contributor to the EAL's accuracy problem.

Radiographs are not a good method for determining working length, claims Clayton.[16] According to him, a file that appears long on a radiograph is 1.2 mm longer. Electronic apex locators, according to ElAyouti, have decreased the prevalence of overestimations of working length. No research examining the impact of root canal curvature on the accuracy of Root ZX apex locators have been reported to date. ElAyouti stated that consistency was caused by the scale bar on the electronic apex locator moving parallel to the file.[17]

The Root ZX II is a third generation EAL (J. Morita Corp., Tokyo, Japan). It utilizes a variety of frequencies and can be used when the canal has a variety of electrolytes. It has been discovered to be more effective than radiography at locating apical constriction.[7] In comparison to other electronic apex locators, Root ZXII's accuracy is superior.[18]

It was discovered that canal curvature affected how well apex locators worked. However, compared to small and curved canals, these Apex locators are more accurate at determining apical constriction in straight and larger canals. In this investigation, the working length of the root canals was determined using Root ZX II after preflaring with Gate-Glidden Burs #1–3. (J. Morita Corp., Tokyo, Japan). EALs accuracy has been found to be greatly improved by preflaring.[19]

Studies have investigated tooth-embedding media that could mimic the impedance values of human tissues for the in vitro evaluation of EALs.[20] These medium had the advantages of being straightforward, simple to use, and allowing for exact control over the experimental conditions investigated. Additionally, more canals might be evaluated in less time than could have been possible using clinical methods. The difficulty of laboratory models to replicate real-world conditions is one of its drawbacks. Alginate, agar, saline, and gelatin are a few of the several media that have been utilized to replicate a clinical setting. The periodontal ligament's colloidal consistency and advantageous electroconductive properties of alginate, which persists around the root and simulates it in the present investigation, led to the adoption of an alginate model.[21]

CONCLUSION

In endodontic therapy, electronic apex locators are very reliable and accurate tools for calculating the working length of root canals. Electronic apex locators' consistency varies from 70% to 94% in different canals, although consistent measurements are extremely accurate, falling between 90% and 93%. The consistency of EAL seems to be affected by canal curvature. However, Root ZX II (J MORITA) provided more precise results in curved canals in this investigation. In conclusion, the present study confirms that these two EALs demonstrated an adequate assessment of the root canal length within 1.2 mm in two apex locators with significance of 0.05. Results from additional research with a larger sample size and alternative sample selection criteria may be more accurate.

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Conflicts of interest - There are no conflicts of interest.

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