

COMPARISON OF WORKING LENGTH DETERMINATION USING TWO ELECTRONIC APEX LOCATORS- AN IN VIVO STUDY

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Abstract- Background and Aim: Traditional methods for establishing working length include the use of radiography which is technique sensitive in both their exposure and interpretation. Electronic apex locators are well known for accurate determination of working length. This study was aimed to compare the working length using two different electronic apex locators and to compare the electronic apex locator method with radiographic method. **Materials & Methods:** Authors studied fifty single rooted teeth of patients of ages 15-30 years. The root canals were further instrumented to size 20 K file. Two apex locators Root ZX II and ProPex II with identical frequencies were used. The position of the major foramen in relation to the anatomic apex and the presence of apical resorption were evaluated for each tooth by surgical microscope at 15X. Measurement was read to the nearest 0.5mm and the actual working length was established by subtracting 0.5mm from the true canal length. The distances measured between the two Electronic Apex Locator groups were compared. **Statistical Analysis and Results:** Data was sent for statistical analysis using statistical software Statistical Package for the Social Sciences. 50 measurements for each Electronic Apex Locators were obtained. The mean distance between the file tip and the minor diameter was +0.0060 mm (± 0.49 mm) for the Root ZX II. The mean distance was +0.0170 mm (± 0.55 mm) for the ProPex II. The Paired sample

t-test showed that there was no statistical significant difference between the results of Root ZX II and ProPex II. Conclusion: The use of Electronic Apex Locators is a reliable method for determining root canal length. The Root ZX II was more efficient in locating the minor diameter (± 0.5 mm) (76% accuracy) than the Propex II (66%). Root ZX II with the auto-stop function had more accurate readings than the Propex II.

Key Words: *Electronic Apex Locators, Working Length, Root Canal, Endodontics*

1. INTRODUCTION

The removal of all pulp tissue, necrotic material and microorganisms from the root canal is essential for endodontic success. The outcome of the treatment of roots with necrotic pulps and periapical lesions is influenced significantly by the apical level of the root filling.¹ Traditionally, the point of termination for endodontic instrumentation and obturation was determined by taking radiographs. Custer outlined an electrical method of finding the apical foramen using electrical conduction.² 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. Radiographs are subjected to distortion and magnification and are technique sensitive in both their exposure and interpretation. Electronic apex locators are particularly helpful when the apical portion of the canal system is obscured by certain anatomic structures, such as impacted teeth, tori, the zygomatic arch, excessive bone density.⁴ The development of electronic apex locators has helped make the assessment of working length more accurate and predictable and used with appropriate radiographs, it allows for much greater accuracy of working length determination.³ The original apex locators proved to be more reliable in a dry canal than in the presence of saline or distilled water John I. Ingle et al⁵. Newer models have the ability to work in both dry and wet conditions, including in the presence of blood, pulp tissue, and the other irrigants.⁶⁻⁷ Any connection between the root canal and the periodontal membrane such as root fracture, cracks and internal or external resorption can be recognized by the apex locators. Multiple function apex locators are becoming more common and have vitality testing functions also.¹ The Root ZX was initially introduced between 1991 and 1994 by Kobayashi.⁶ This study was aimed to compare the working length using two different electronic apex locaters and to compare the electronic apex locator method with radiographic method.

2. MATERIALS & METHODS

This study was conducted in the department of Conservative Dentistry and Endodontics wherein fifty single rooted teeth of patients of ages 15-30 years were studied. Teeth scheduled for extraction for orthodontic or prosthodontic and periodontal reasons were used. Approval by the institutional review and ethical board was obtained and written consent was obtained from each patient. Following access opening, coronal portion of the canal was flared using Gates Glidden drills, 2 to 4 sizes. 15 size K file was used to negotiate the canal to the working length with the help of the electronic apex locaters. If the file was a snug fit of the apex the tooth was selected for the study. All teeth with apical sizes greater than size 15 K file were not selected for the study. The canals were further instrumented to size 20 K file, to achieve a snug fit at the apex. For the Root ZX II (J. Morita Corporation, Tokyo, Japan), the

lip clip was attached to the patients lip and the electrode connected to the file (Figure 1). The clip was applied to the patients lip and no.20 K-file connected to the electrode of the device was apically advanced in the canal, until it reached the previously calibrated 0.5mm sign on the screen of the device, which is accepted as the apical constriction (Figure 2). At the meter's 0.5 reading, the length of the file was measured and the value recorded. Using the ProPex II (Dentsply, Switzerland), the file was advanced into the canal to just beyond the foramen, as indicated by the red light and the warning signal (Figure 3). The file was then withdrawn until the reading of the Electronic Apex Locator showed a consistent '0.5'. After the third measurement composite resin (Ceram X; Dentsply, Konstanz, Germany) stent was placed around the file and the resin cured to ensure stable stop for repositioning the file into the canal (Figure 4). In each case the Electronic Apex Locators were randomly used. Radiographs were taken by Paralleling technique. After extraction teeth were placed in 5.25% sodium hypochlorite solution for 15 minute, and stored in saline solution. The position of the major foramen in relation to the anatomic apex and the presence of apical resorption were evaluated for each tooth by surgical microscope at 15X. Apical 4 mm of the root was shaved by finishing bur under vision of surgical microscope at 15X original magnification until the file could be seen through a thin layer of dentin (Figure 5). The file was placed into the canal until the tip was visualized from the tangential angle at the apical exit using 15X magnification (Figure 6 and 7). Radiographic assessments were also attempted (Figure 8 and 9). The first image was made with the composite pattern for the measurement with Root ZX II. The second image was made with the composite pattern for the working length determination with ProPex II. The distance from the end of the file to minor diameter was measured using a grid of 0.5mm & recorded. Measurement was read to the nearest 0.5mm and the actual working length was established by subtracting 0.5mm from the true canal length. The distances measured between the two Electronic Apex Locator groups were compared using a paired samples t test to determine the accuracy of each Electronic Apex Locator in relation to minor diameter.

Figure 1: ROOT ZX II and PROPEX II



Figure 2: Working length measurement by ROOT ZX II



Figure 3: Working length measurement by PROPEX II



Figure 4: Preparation of the composite stent



Figure 5: Surgical Microscope



Figure 6: File tip visualization at the apical exit (ROOT ZX II)

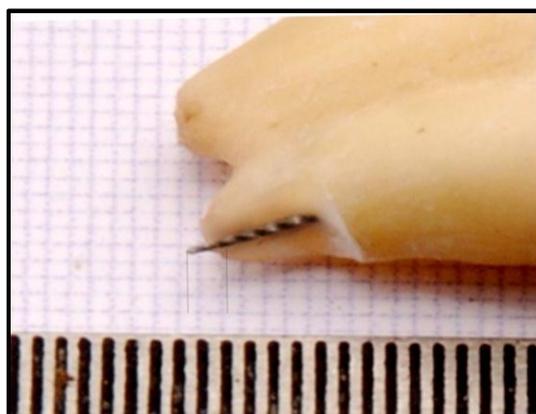


Figure 7: File tip visualization at the apical exit (PROPEX II)

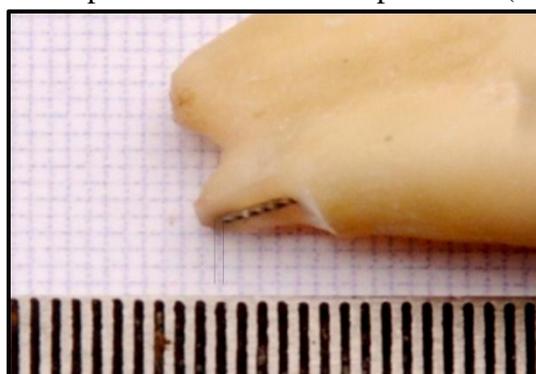
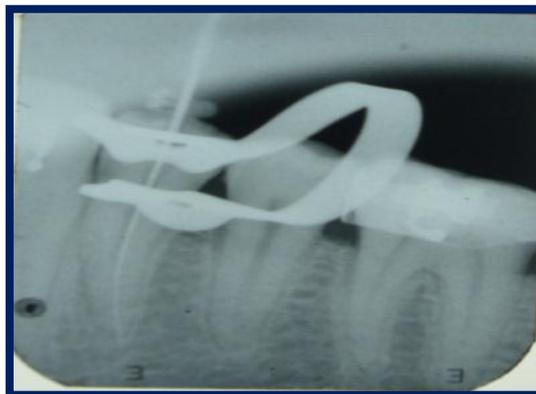
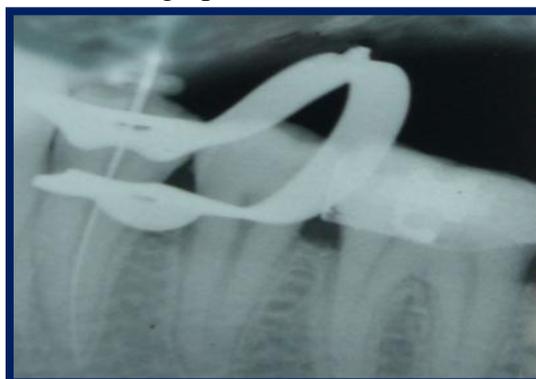


Figure 8: Radiographic Assessment (ROOT ZX II)**Figure 9:** Radiographic Assessment (PROPEX II)

3. STATISTICAL ANALYSIS AND RESULTS

In the present study, all noticeable findings and data were compiled in rationally. Compiled data was sent for statistical analysis using statistical software Statistical Package for the Social Sciences (IBM Inc., Armonk, New York, USA). The narrowest part of the canal is called the Apical Constriction, and is also known as the Minor Diameter. The minor diameter represents the transition between the Pulpal and the Periodontal tissue. Each tooth served as its own control; thus, 50 measurements for each Electronic Apex Locators were obtained. The mean distance between the file tip and the minor diameter was $+0.0060$ mm (± 0.49 mm) for the Root ZX II. The mean distance was $+0.0170$ mm (± 0.55 mm) for the ProPex II (Table 1). Within the limits, minor diameter ± 0.5 mm, the target interval was located in 76% of cases with the Root ZX II. 24% of the measurement fell outside the target interval and were beyond the apical constriction for the defined limit. The ProPex II was within the limits of ± 0.5 mm to the minor diameter in 66 % of the cases; 34% of the measurements were beyond the apical constriction (Table 2). The Paired sample t-test showed that there was no statistical significant difference between the results of Root ZX II and ProPex II in determining of the minor constriction ($p=0.908$). Working length determined by the conventional radiographic method also showed less deviation. Root ZX II and ProPex II showed lesser deviation when compared with the radiographic method. 4 out of 50 showed

file beyond the apex with ProPex II and 2 out 50 showed with Root ZX II. Percentages of file beyond the apex were 2% with ProPex II and 1% with Root ZX II. Therefore, no significant difference was seen comparing the Root ZX II and ProPex II with the radiographic method.

Table 1: Distance from the file tip to minor diameter

	NUMBER OF TEETH	MEAN	MEDIAN	STANDARD DEVIATION	MINIMUM	MAXIMUM
ROOTZX II	50	.0060	.0000	.49	-.85	1.60
PROPEX II	50	.0170	.00	.55	-.95	1.15
Paired sample t test: no statistically significant differences. Minus sign indicates file position coronal to apical constriction						

Table 2: Position of the file tip relative to the minor diameter as determined by the ROOT ZX II and the PROPEX II

DISTANCE FROM MINOR DIAMETER (MM)	ROOT ZX II		PROPEX II	
	N=50	%	N=50	%
BELOW TO -1	0	0	0	0
-1 TO -0.5	9	18	6	12
-0.5 TO 0	29	58	27	54
0 TO 0.5	3	6	9	18
0.5 TO 1	8	16	6	12
1 TO ABOVE	1	2	2	4
* Negative value indicates file position coronal to the minor diameter				

4. DISCUSSION

Accurate working length is a crucial factor for the success of endodontic therapy. Working length establishes the apical extent of canal preparation and apical stop. Failure to accurately determine the working length may lead to apical perforation, pushing of debris beyond the apex and overfilling, with increased incidence of postoperative pain or may also lead to incomplete instrumentation and under filling with attendant problems. In addition, ledge formation may develop, short of the apex, making adequate treatment or retreatment extremely difficult or impossible. Finally, apical percolation may develop into the unfilled “dead space” at the apex. This could result in a prolonged healing period or continued periradicular lesion and increased incidence of failure.^{1,5,7,8,13} Gordon stated that ‘the proper point to which root canals should be filled is the junction of the dentin and the cementum and

that the pulp should be severed at the point of its union with the periodontal membrane'.¹ The cementodentinal junction (CDJ) is the anatomical and histological landmark where the pulp ends and periodontal ligament begins. Root canal preparation techniques aim to make use of this potential natural barrier between the contents of the canal and the apical tissues. It is generally accepted that the preparation and obturation of the root canal should be at or short of the apical constriction. Welk concluded that a root canal had two sections, a longer conical section in the coronal region consisting of dentine and a shorter funnel shaped section consisting of cementum located in the apical portion. The shape of this apical portion is considered to be an inverted cone; its base being located at the major apical foramen.⁹ The apex of the inverted cone is the minor foramen that is often thought to coincide with the apical constriction regarded as being at or near the cement-dentinal junction (CDJ). The Major apical foramen is not a uniform shape but can be asymmetrical.¹⁰⁻¹⁶ The root canal terminus is considered by many to be the CDJ. In some instances the CDJ coincides with the pulp and periodontal tissue junction, where the pulp tissue changes into apical periodontal tissue. Theoretically, the CDJ is the appropriate apical limit for root canal treatment as at this point the area of contact between the periradicular tissues and root canal filling material is likely to be minimal and the wound smallest. The CDJ is not a constant or consistent feature, for example the extension of the cementum into the root canal can vary. Therefore, it is not an ideal landmark to use clinically as the end point for root canal preparation and filling.¹⁷⁻²⁵ The apex of the root has a specific resistance to electrical current, and this is measured using a pair of electrodes typically hooked into the lip and attached to an endodontic file. The electronic principle is relatively simple and is based on electrical resistance when a circuit is complete (tissue is contacted by the tip of the file), resistance decreases markedly and current suddenly begins to flow. According to the device, this event is signalled by a beep, a buzz, a flashing light, digital readouts, or a pointer on a dial. Electronic apex locators with additional functions were developed in the late 1990s.²⁶⁻³² Electronic apex locators are particularly useful when the apical portion of the canal system is obscured by certain anatomic structures, such as impacted teeth, tori, the zygomatic arch, excessive bone density, overlapping roots, or shallow palatal vaults. Suspected periodontal or pulpal perforation during pinhole preparation can be confirmed by all apex locators.^{5,33,34,35} The (fourth generation) apex locators measure resistance and capacitance separately rather than the resultant impedance value. Though it is claimed to provide high accuracy but more studies are required. Fourth generation devices include Bingo 1020/Ray-pex 4, Elements Diagnostic Unit & Apex Locator. PROPEX (Dentsply Maillefer, Ballaigues, Switzerland) is a multi-frequency based apex locator which uses multiple frequencies to determine root canal length. The objective of the study was to compare the accuracy of two electronic apex locators (Root ZX II and ProPex II) and its comparison with radiographic method. To reduce over preparation a withdrawal of the instruments of 0.5mm might be helpful and was recommended by Wrbas et al.⁷ Therefore 0.5mm from the apical foramen was selected, as the actual working length, that means the entire canal instrumentation and obturation should terminate at this point. The results of the present study showed that that there was no statistical significant difference between the results of Root ZX II and ProPex II in determining of the minor constriction ($p=0.908$). The result of the present study are in agreement with studies of Wrbas et al., Tselnik et al., Chris Siu et al., Aaron R. Welk et al,

G. Plotino et al, Goldberg et al, Sandra joia et al with the third generation apex locator (Root ZX II) 76% of the readings coincided with the apical constriction within the limits of ± 0.5 mm to the minor diameter.^{3,7,10,11,12,14,15} Numerous studies have reported on the accuracy of Electronic Apex Locators in determining the location of the minor diameter. These studies differ in establishing the reference point from which measurement accuracy is determined some authors measured from the major diameter or apical foramen.³⁶⁻⁴³ The position of the file tip is derived from the simultaneous measurement of the impedance of two different frequencies that are used to calculate the quotient of the impedances.⁴⁴⁻⁴⁸

5. CONCLUSION

Within the limitations, they stated that the third generation apex locators are reliable tool for the determination of the working length, even though the use of intra oral radiography cannot be ignored. A technique that combines the use of electronic devices and radiograph will certainly reduce the radiation exposure, since the adjustment of the lengths of the file would be minimal and repeat radiograph not required. The use of Electronic Apex Locators is a reliable method for determining root canal length. The Root ZX II was more efficient in locating the minor diameter (± 0.5 mm) (76% accuracy) than the Propex II (66%). Root ZX II with the auto-stop function had more accurate readings than the Propex II; however the difference was not significant. Nevertheless, our study results should be interpreted as suggestive. Authors anticipate few other genuine studies to be conducted with larger sample size and wider study parameters so as to establish certain concrete norms in these perspectives.

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