

Comparison of Accuracy of Two Electronic Apex Locators and Evaluation of Impact of Apical Patency on Accuracy: An In Vitro Study

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Abstract

Objective(s): Aim of the study was to compare accuracy and to investigate the importance of apical patency of 2 apex locators - ROOT ZX MINI and PROPEX PIXI.

Materials and Methods: Under a dental operating microscope with an X25 magnification, the actual working length was measured. A size #10K file was inserted into the root canal, progressed until it was visible at the apical foramen, and then removed. The working length was then calculated. Readings of the 2 apex locators are then compared with the actual microscopic working length. The apical foramen is then blocked, and files are then inserted to the working length that was previously determined. To calculate the measurement error, the variation in apex locators' values following obstruction is compared to their initial measurements prior to blockage.

Results: When Root ZX micro and Pixi apex locators' mean working lengths (measured in mm) were compared before and after apical blocking using a Student Paired t Test, the difference between the two was significantly greater after the apical block. After apical blocking, the estimated error distance between the two EALs' working lengths did not demonstrate a discernible difference. [P=0.72].

Conclusion(s): When compared to Propex pixi, Root ZX mini was statistically more accurate. The accuracy of apex locators is negatively impacted by apical foramen obstruction, which was more obvious in Root ZX than Propex pixi.

1. Introduction

Determination of apical limit and position of canal terminus plays a pivotal role in effectively carrying out root canal therapy. A wide array of techniques including tactile feedback from endodontic instruments, radiographs and electronic apex locators are used for the estimation of apical terminus. Electronic apex locator (EAL) has become an essential tool for working length determination because it overcomes the drawbacks of the 2-dimensional technique sensitive periapical radiography. [1] Sunada found that the resistance to electric current offered by

the oral mucosa and periodontal ligament can be represented by numerical values. More advanced devices were then developed in successive generations. [2] There has been a series of generations since the first launching of apex locator, which relied on direct electrical current and resistance. All the recent generations rely on alternating current of more than one frequency and on impedance rather than resistance. [3] The main concept of all of these generations is electrical conductivity between the attached file clip and the lip clip where the root dentin acts as an insulator and the periodontal ligament is the conductor.

Oral mucosa, periodontal ligament and lip clip attached to it forms a closed circuit as current passes through it. [4]

2. Materials And Methods:

Teeth Selection and Preparation:

The study includes 40 extracted human mandibular premolars with fully developed roots. Teeth were collected, cleaned with 5.25% sodium hypochlorite (NaOCl) for ultrasonic scaling and disinfection, and then kept in Chloramine T solution until needed. Under a dental operating microscope (Labomed; Labo America, Fremont, CA) at X25 magnification, the root surfaces and apical areas were examined to look for potential fractures and assess the apex maturity. The research did not include teeth with open apices, fractures, calcified canals, or resorption.

Actual Working Length Determination (Microscopic Working Length Measurement): The occlusal surface of the teeth was smoothed to serve as a stable reference point for the measurement of working length using a diamond disc. Using #10 K-file (Mani files, Japan), the canals' patency was verified, and then 5 mL of 5.25% NaOCl was used to irrigate them. The numbers 1 through 40 were progressively assigned to forty experimental samples. Under an X25 dental operating microscope, the #10 K-file was advanced into the root canal until it was visible at the apical foramen. An endodontic measuring ring was

used to measure the length after the file was removed, and values were recorded down to the nearest 0.01 mm. Every measurement was made three times, and the mean of the results was taken as the measurement that best represented the sample. Then, 0.5 mm were removed from this measurement, and the actual working length was noted (AWL).

Electronic Working Length Determination:

Here, a plastic mould with a 5 cm radius was utilized, and enough alginate was put within the moulds to encase the roots, leaving almost 5 mm of the root surface exposed (Figure 1). Prior to measurements, both apex locators were calibrated to guarantee appropriate operation. The lip clip was placed within the alginate during setting, which was followed by electronic measurement. Within two hours, all of the electronic measurements were completed. According to the recommendations of the manufacturers, Root ZX mini (Morita Co, Tokyo, Japan) and Propex pixi (Dentsply Maillefer, Switzerland) were utilised. A silicone stopper and Root ZX small #10 K-file were inserted until the apex reading was obtained. The file was subsequently withdrawn to the display green flashing bar. The file was inserted into the root canal for Propex Pixi until the first red bar appeared, and it was then pulled out until the flashing orange bar 00 reading was attained. Each sample's level of penetration into the root canal was assessed using an EAL and compared to an AWL.



Figure 1: Plastic mould stimulating oral environment for apex locator

Measurements of Working Length after Canal Blockage:

In order to develop dentinal mud or plug, canal obstruction was purposefully created in the experimental samples by filing the cervical dentin using Hedstrom stainless steel files (MANI, Japan). Until the loss of canal patency was confirmed, this dentinal plug was then pushed into the apical foramen of the root canal, where the #10-K file could only extend to the previously documented length and could not go any further. For both of the apex locators,

#10 K-file was inserted during electronic measurement to the same previously reported length before new measurements were taken. If the reading stayed consistent for at least 5 seconds, values were accepted as creditable. The differences between each individual EAL's reading before and after obstruction were computed. Positive difference meant the measured length was longer than it was before the obstruction, whereas negative readings showed the length was shorter, and 0.0 meant the measurements were coincident. The two apex locator readings were compared using the student paired t test.

3. Results**Mean working length b/w actual and EAL based working length:**

Table 1. Comparison of mean working length b/w actual and EAL based working length determination using Repeated measures of ANOVA followed by Bonferroni's post hoc test

Working length	N	Mean	SD	Min	Max	P-Value ^a	Sig. Diff	P-Value ^b
Actual	40	21.05	1.54	18.0	24.0	0.02*	A vs R	0.07
Root ZX mini	40	20.98	1.57	17.9	24.0		A vs P	0.02*
Pixi	40	20.85	1.59	17.8	24.0		R vs P	0.19

* Statistically Significant

The test result demonstrated a statistically significant difference between the working length as assessed by the manual technique and the EAL, with a P value of 0.02 (Table1). The results of a pairwise comparison of the working lengths obtained by the various approaches showed that the mean working length calculated by the manual method was much greater than the working length determined by the Pixi EAL, and the difference was statistically significant at P=0.02. However, there was no substantial difference between the Root ZX mini and Pixi EAL working lengths [P=0.19] or between the Manual and Root ZX mini EAL working lengths [P=0.07] (Table1).

Error distance measures by 2 EAL before apical blockage

The estimated error distance between the two EALs' working lengths prior to apical obstruction did not reveal a statistically significant difference [P=0.66] (Table2). The majority of the findings in both EALs showed 80 to 90% error difference of 0 mm compared to actual working length & expressed an accuracy in working length determination. 5 to 7.5% of error distance was recorded with -1 to -0.5 mm & 0.5 to 1mm in both the EALs. However, 5% of Pixi EAL showed >1.0 mm error distance as compared to Root ZX mini EAL, before apical blockage (Figure 2).

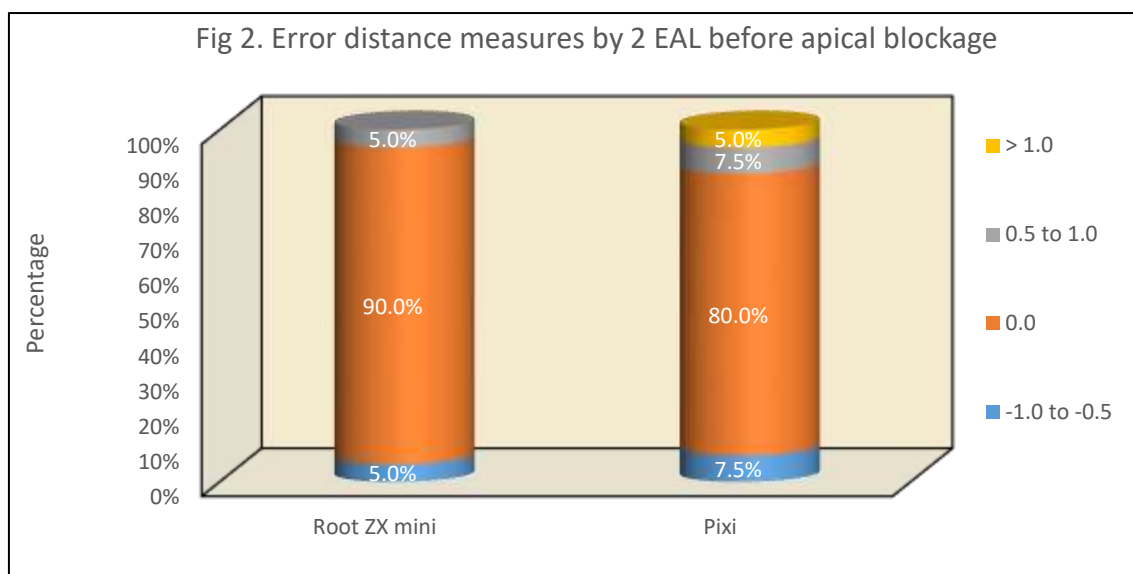


Figure 2. Bar graph showing the error distance measurement by 2 EAL before apical blockage

Table 2. Comparison of error distance measures by 2 EAL before apical blockage using Marginal Homogeneity test

Distance	Root ZX mini		Pixi		P-Value
	n	%	n	%	
-1.0 to -0.5	2	5.0%	3	7.5%	0.66
0.0	36	90.0%	32	80.0%	
0.5 to 1.0	2	5.0%	3	7.5%	
> 1.0	0	0.0%	2	5.0%	

* Statistically Significant

Table 3. Comparison of error distance measures by 2 EAL after apical blockage using Marginal Homogeneity test

Distance	Root ZX mini		Pixi		P-Value
	n	%	n	%	
-1.0 to -0.5	0	0%	2	5.0%	0.72
0.0	35	87.5%	30	75.0%	
0.5 to 1.0	5	12.5%	7	17.5%	
> 1.0	0	0%	1	2.5%	

* Statistically Significant

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The estimated error distance between the two EALs' working lengths following apical blockage did not demonstrate a statistically significant difference [P=0.72] (Table 3). The majority of the results in both EALs demonstrated an accuracy in working length determination with an error difference of 0 mm of 75

to 87.5% compared to the actual working length. 12.5 to 17.5% of error distance was recorded with 0.5 to 1 mm, in both the EALs. However, 5% of Pixi EAL showed -1.0 to -0.5 & 2.5% of > 1 mm error distance as compared to Root ZX mini EAL, after apical blockage.

Table 4. Comparison of mean Working length (in mm) between before & after apical blockage in Root ZX mini & Pixi apex locators using Student Paired t Test

Apex Locators	Apex Locators	N	Mean	SD	Mean Diff	P-Value
Root ZX mini	Before Apical Blockage	40	20.98	1.57	0.18	0.009*
	After Apical Blockage	40	20.80	1.66		
Pixi	Before Apical Blockage	40	20.85	1.59	0.19	0.007*
	After Apical Blockage	40	20.66	1.65		

* Statistically Significant

The test results demonstrate that the mean working length determined before and after apical blockage in Root ZX mini and Pixi showed significant reduction in the mean working length after apical block as compared to before apical blockage. This difference was statistically significant at P<0.001 respectively (Table 4, Figure 3).

4. Discussion

Through the detection of the transition from pulp to periodontal tissue, electronic apex locators help odontometry, a procedure that was previously carried out using radiography. Anatomically, this transition is extremely near to the apical constriction. Therefore, the precision and effectiveness of root canal therapy are improved with electronic apex locators. [5]

Alginate, agar, saline, and gelatin are some of the materials that may be used to simulate a clinical oral cavity scenario. Alginate models provide a number of benefits, including the ability to mimic the colloidal consistency of the periodontal ligament, exhibit advantageous electroconductive characteristics, and remain close to the root. So, in the current investigation, the alginate model is employed. [6]

A dental operating microscope is yet another useful device that may be used to find perforations during

surgical endodontic procedures and root canal therapy. [7]

Apex locators come in a variety of generations, from the first to the sixth, and are all readily accessible on the market.

The resistance apex locators of the first generation of apex finding devices work by measuring the amount of direct current flow resistance. As the tip of the reamer gets closer to the canal apex, the resistance value increases to up to 6.5 k (current: 40 mA).

The impedance apex locators of the second generation of apex locators measure impedance, which is the resistance to the passage of alternating current.

Third-generation apex locators operate under the premise that, in a biological setting, the reactive component promotes the passage of alternating current more for higher frequencies than for lower. This theory states that a tissue will block the lower frequency current more than the higher frequency current when two alternating currents of different frequencies are passing through it. As impedance is closely dependent on the frequency of current flow of the circuit, these devices are referred to be "frequency dependent." These apex locators then translate relative magnitudes of the impedances into "length" information. Additionally, as these devices measure impedance

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rather than frequency, the name "comparative impedance" would be more suitable.

The impedance is calculated using "fourth-generation" apex locators at five different frequencies.

According to D'Assunção et al. [8], the Root ZX II was 97.4% accurate in determining the RWL within the tolerances of 0.5 mm. According to Teslnik et al., Root ZX has an accuracy rate of 89.9% and a margin of error of 1. [9]

The accuracy rate for Root ZX was 62.5% for da Silva and Alves Flavio [10], and 68.8% for Aguiar et al for Root ZX. Both groups reported accuracy within the range of 0.5 mm. [11]

According to a research by Gehlot PM et al, PIXI had an accuracy rate of 83.3%. [12]

Current study compared the working length determined by EAL and by manual method and it was observed that pairwise comparison between different methods revealed that the mean working length determined by manual method was significantly higher than the Pixi EAL determined working length.

While both EALs displayed an error difference of 10% or less when compared to the actual working length, the Pixi EAL had a larger error distance (>1.0 mm) than the Root ZX mini EAL. A significant difference was found when comparing the working length after apical blockage with >15% of cases showing > 0.5 mm error distance to the results obtained before apical blockage, but the error distance estimated between EAL determined working length after apical blockage did not show a significant difference between 2 EALs. This study compares the mean working length measured in Root ZX mini and Pixi before and after apical blockage, revealing a substantial decrease in the mean working length following apical blockage compared to before apical obstruction.

5. Conclusions

From the present study it can be concluded that Root ZX mini was statistically more accurate compared to Propex pixi. EALs showed 80% for Propex Pixi and 90% for Root ZX mini error difference of 0 mm compared to actual working length & expressed an accuracy in working length determination. The accuracy of apex locators is negatively impacted by

apical foramen obstruction, which was more obvious in Root ZX than Propex pixi.

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CONFLICT OF INTEREST

"No potential conflict of interest relevant to this article was reported".

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