

Evaluation Of Root Zx, Apex Id, Propex Pixi And Raypex 6 In Teeth With Wide Apical Foramen An In-Vitro Study.

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Abstract

Aim: To evaluate the efficacy of ROOT ZX, APEX ID, PROPEX PIXI, and RAYPEX 6 apex locators in determining working length with different apical diameters (at 0.0, 0.32, 0.57, 0.72mm apical widening)

Materials and methods:

Sixty extracted single rooted premolars were included in the study. Actual working length was determined by observing under 20X magnification with help of RAPID I microscope until 10 K file was visible at apical foramen. File was withdrawn 0.5mm from this point, stopper adjusted, file was removed and length was measured.

Teeth were divided into four groups depending on the apical diameters:

Group I (n=15): Canals with no preparation.

In GROUP II, III & IV, after enlarging the canal, file was advanced beyond 1mm.

Group II (n=15): Canals were enlarged until size 30 K-file.

Group III (n=15): Canals were enlarged until size 55 K-file.

Group IV (n=15): Canals were enlarged until size 70 K-file

Root canal measurements with electronic apex locators (EALs) were recorded.

Statistical analysis was performed using Fisher exact test & one way anova. Significance was set at $P < 0.05$

Results: There was no statistically significant difference between the accuracy of four different apex locators, but there was significant difference seen between Group I and Group IV.

Conclusion: The electronic apex locators can be used, only as an adjunct to radiographs in determining the working length of teeth with wide apical diameters. Raypex 6, newer generation apex locator performed best in present study.

Keywords: Apex ID, EALs, Propex pixi, Raypex 6, Root ZX.

Introduction

The endodontic success depends on the complete eradication of all pulp tissue, necrotic material and microorganisms, along with adequate cleaning, shaping and filling of the root canal. This can only be achieved by determining the exact working length.¹

According to the American Association of Endodontists (AAE) (2003), working length is defined as "the distance from a coronal reference point to the point at which canal preparation and filling should terminate".

The apical constriction is the recommended end point of instrumentation and obturation since the tooth pulp is narrow at the apical constriction, so the wound is minor, potentially providing optimal healing conditions.²

Also, extrusion of root canal filling material beyond the canal acts as potent irritant leading to failure of the treatment. According to the literature, it is assumed that the periodontium starts at apical constriction, and instrument or filling material beyond this point is considered as overinstrumentation/overextension.³

The location of the apical constriction is considered to be 0.5-1 mm short of the anatomical apex.²

Radiographs, though traditionally used, do not provide location of the apical constriction which is considered to be the terminal point of shaping & obturation. Also, problems associated with the radiographic method of working length estimation which are anatomic structure interferences, projection errors, radiation exposure and two dimensional image, lead to the invention of newer methods.⁴

One of the innovations in endodontics is electronic devices for detecting the canal terminus. The use of electronic apex locators eliminates the drawbacks associated with radiographic methods. An electronic method for working length determination was first investigated by Custer in 1918 and later in 1942 Suzuki studied the flow of current through teeth of dogs and concluded having constant electrical resistance values between instrument in root canal and electrode on mucous membrane.

Sunada constructed a device based on these principles that the electrical resistance between mucous membrane and the periodontium registered same values irrespective of person's age, shape of tooth or type.⁵

RootZX (third generation) (RZX, J. Morita Corp., Tokyo, Japan) apex locator is considered as the gold standard and it works on the principle of dual frequency (8KHz and 400Hz) to determine the working length.⁶ They are based on the fact that different site in canals give difference in the impedance between low and high frequencies. The quotient of impedances reduces at apical constriction.⁴

RootZX has self calibrating micro processors and uses ratio method to process the mathematical quotient and algorithm calculations required to give accurate readings. Disadvantage being sensitivity to canal fluid and need of fully charged battery which lead to inventions of further generation.⁷

ApexID (fourth generation) (AID; SybronEndo, Orange, CA) has operating mechanism similar to Rootzx with different frequencies (0.5 & 5.0 kHz).⁸ It measures resistance and capacitance separately. Hence, better accuracy and less error. But, a significant disadvantage is that they need to perform in relatively dry canals.⁴

Propex pixi (PIXI, Dentsply Maillefer, Ballaigues, Switzerland) fifth generation apex locator uses multiple frequencies and works by calculating the root mean square values of electrical signals to give accurate readings.⁹ Fifth generation apex locators have best accuracy with moist canal conditions (blood, saliva, edta, NaOCl) but considerable difficulties seen in dried canals.

Raypex 6 (sixth generation) (RAY; Munich, Germany) adaptive apex locators adapts itself to the conditions of the root canal (dry or wet) to provide accurate readings¹⁰.

Limited studies are available regarding accuracy of different generation apex locators with different apical diameters.

So, the aim of the present study was to evaluate the efficacy of ROOT ZX, APEX ID, PROPEX PIXI, AND RAYPEX 6 apex locators in determining working length with different apical diameters (at 0.0, 0.32, 0.57, 0.72mm apical widening)

Materials and Methods

Eighty extracted single rooted premolars were included in the study. Teeth were stored in formalin until further use.

For standardization of length of teeth, incisal surfaces of the teeth were trimmed with a diamond bur and reference point was obtained.

Access cavity preparations were prepared using high speed aerotor with water coolant.

Actual working length was determined by observing under 20X magnification with help of RAPID I microscope until 10 K file was visible at apical foramen. File was withdrawn 0.5mm from this point, stopper was adjusted, file was removed and length was measured with the help of endo gauge.

Teeth were divided into four groups depending on the apical diameters:

Group I (n=15): Canals with no preparation (no apical enlargement)

Group II (n=15): Canals were progressively enlarged until a size 30 K-file & file was advanced 1 mm beyond the AF to achieve apical diameter of 0.32mm.

Group III (n=15): Canals were progressively enlarged until a size 55 K-file & file was advanced 1 mm beyond the AF to achieve apical diameter of 0.57mm.

Group IV (n=15): Canals were progressively enlarged until a size 70 K-file & file was advanced 1 mm beyond the AF to achieve apical diameter of 0.72mm.

All four apex locators were used in each group to measure the working length.

Alginate molds were prepared. All samples were embedded in an alginate filled mold.

For group 0, K-file with resistance at the apical region was selected and attached to the EALs to determine the working length while master apical files were selected for other groups.

For Root ZX, working length determination was established at the point when the screen displays the line just in the middle of apex and mark 1 which corresponds to 0.5 mm short of radiologic apex [Figure 1].

For Apex ID, the point between APEX AND MARK 1 was considered [Figure 2].

For Propex PIXI, the marking of 0.5 mm was considered [Figure 3].



Figure 1: Experimental set-up for ROOT ZX

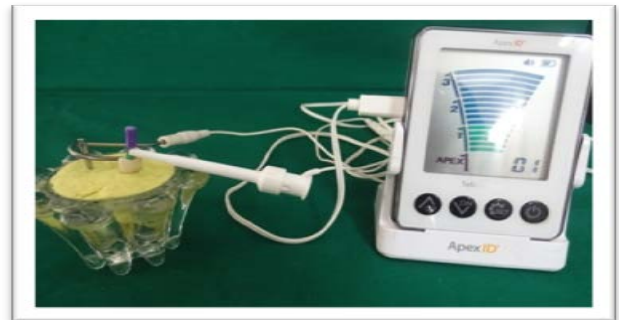


Figure 2: Experimental set-up for APEX ID



Figure 3: Experimental set-up for PROPEX PIXI

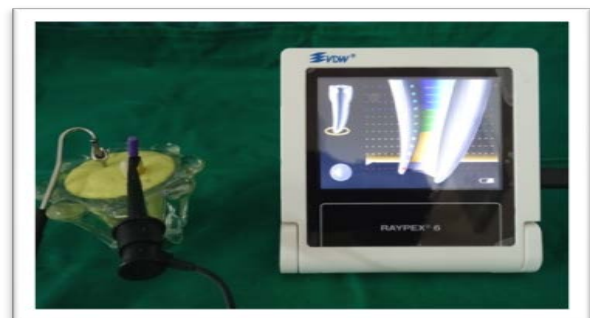


Figure 4: Experimental set-up for RAYPEX 6

For Raypex 6, the third green line, just before the yellow lines, which corresponds to 0.5 mm short of radiographic apex, was considered [Figure 4].

Statistical Analysis

The results of apex locators were assessed both intergroup and intra-group. Statistical analysis was performed with Fisher exact test & One way anova. Significance was set at $P < 0.05$.

Results

Table 1, Table 2, Table 3 and Table 4 represent the accuracy of RootZX, Apex ID, Propex Pixi and Raypex 6 respectively within ± 0.5 mm and ± 1 mm.

The inter-group evaluation of all four apex locators was represented in Table 5.

Within ± 0.5 mm, all devices performed best at G 0. (Control group)

Their accuracy significantly decreased at G32, G57 and G72.

There was significant difference seen between Group 0 and Group 72.

Raypex 6 and Root ZX revealed better results than Apex ID and Propex pixi.

As regard the accuracy of the Apex ID & Propex Pixi devices, no significant difference was seen among the data recorded at $p < 0.05$. However, the readings of the Root ZX and the Raypex 6 were identical and showed higher degree of accuracy reaching 86% & 87%.

TABLE 1: The distance of file EMs to AWLs for Root ZX. *0 indicates EM is exactly the same as AWL. Negative values indicate EM is shorter than AWL. Positive values indicate EM is exceeding AWL .

DISTANCE TO APEX	G0	G32	G57	G72
SAMPLE SIZE	15	15	15	15
1 TO 0.51	1	1	1	2
0.5 TO 0.01	2	3	3	4
0	3	2	2	1
-0.01 TO -0.5	8	6	6	5
-0.51 TO -1	1	3	3	3

TABLE 2: The distance of file EMs to AWLs for Apex ID. *0 indicates EM is exactly the same as AWL. Negative values indicate EM is shorter than AWL. Positive values indicate EM is exceeding AWL

DISTANCE TO APEX	G0	G32	G57	G72
SAMPLE SIZE	15	15	15	15
1 TO 0.51	0	2	1	1
0.5 TO 0.01	2	2	3	2
0	3	2	2	1
-0.01 TO -0.5	7	6	6	6
-0.51 TO -1	3	3	3	5

TABLE 3: The distance of file EMs to AWLs for Propex Pixi. *0 indicates EM is exactly the same as AWL. Negative values indicate EM is shorter than AWL. Positive values indicate EM is exceeding AWL

DISTANCE TO APEX	G0	G32	G57	G72
SAMPLE SIZE	15	15	15	15
1 TO 0.51	1	1	1	0
0.5 TO 0.01	2	2	4	3
0	2	2	1	1
-0.01 TO -0.5	8	7	6	5
0.51 TO -1	2	3	3	6

TABLE 4: The distance of file EMs to AWLs for Raypex 6. *0 indicates EM is exactly the same as AWL. Negative values indicate EM is shorter than AWL. Positive values indicate EM is exceeding AWL

DISTANCE TO APEX	G0	G32	G57	G72
SAMPLE SIZE	15	15	15	15
1 TO 0.51	1	1	0	0
0.5 TO 0.01	3	3	2	1
0	2	2	2	1
-0.01 TO -0.5	8	7	8	8
0.51 TO -1	1	2	3	5

TABLE 5: The inter-group (FOUR EALs in the same apical diameter size) comparison of the accuracy of the FOUR apex locators within ± 0.5 mm in each group

DISTANCE TO APEX	ROOT ZX	APEX ID	PROPEX PIXI	RAYPEX 6
G0	13	12	12	13
G32	11	10	11	12
G57	11	11	11	12
G72	10	9	9	10

Discussion

Suzuki discovered a constant electrical resistance of 6.5 kΩ between the periodontium and oral mucous membrane which became the basis for the evolution of the apex locators.

First generation apex locators are based on resistance while second generation apex locators are impedance based. Owing to the drawbacks of first and second generation, lead to the innovation of third generation apex locators which calculated the quotient by ratio method to display precise readings.⁴ Owing to its disadvantage of being sensitivity to canal fluid and need of fully charged battery lead to inventions of further generation.⁷

The need of relatively dry canals for accuracy of fourth generation apex locators and moist canals for fifth generation apex locators have led to inventions of sixth generation apex locators (Adaptive apex locators) which eliminates the need for drying or moistening the canals, and it also works with precision in presence of blood.⁴

Also, along with the disadvantages of radiographs, the history of over and under preparations and compromised obturation has made it mandatory to use electronic apex locator along with traditional radiographic method.

Number of factors may influence the accuracy of EALs, such as the size of the apical foramen, the type and size of the measuring file, the irrigation solution used, and electroconductivity of the pulp.^{11, 12}

In clinical practice, enlarged apical foramina may be the result of anatomic features, over instrumentation, root resorption, or incomplete apical root formation, and they may pose challenges to electronic working length (EWL) measurement during root canal treatment.

Wu et al., reported a direct relationship between the size of the apical foramen and the accuracy of electronic apex locators.¹³ Lizi Huang showed that the accuracy was influenced by two factors: moisture content of the root canal and diameter of the apical foramen.¹⁴ T.J. Stein et al., stated that anatomical features of major and minor apical diameter has an influence on the discrepancies associated with electronic apex locators.¹⁵

In 1994, the Root ZX (J. Morita Corp, Tokyo, Japan) was introduced to overcome the problems associated with first & second generation apex locators.

Root ZX works by simultaneously measuring the impedance values at two frequencies i.e. 0.4 and 8.0 kHz, & then calculates their quotient value to provide accurate values.^{4, 16}

In accordance with study of Manuela Herrera et al., Root ZX apex locator is accurate under a diameter size of 0.6 mm. In the case of diameters of 0.7 to 0.8 mm, adjustment of files to the foramen was mandatory to maintain accuracy, whereas above size 0.9 mm the device is not accurate.¹⁷

Also, supported by the study of M. Kovacevic, T. Tamarut.¹⁸

A study by Shabahang et al. found Root ZX to be 96.2% effective in determining the location of the apical foramen to within 0.5mm.¹⁹

No significant difference is seen between apex id, propex pixi and rayplex in a study conducted by Tiago Nepomuceno Oliveira et al.²⁰

In accordance with the study of George M. Guise et al., the Root ZX II Apex locator was the most accurate at locating the apical foramen compared to fourth generation apex locators.²¹

According to the study of Sreeha Kaluva Kolanu et al, propex pixi apex locator is accurate under a diameter size of 0.6mm with whatever file size is used.²²

In the present study, no significant difference was seen with different apex locators but accuracy was better with the latest sixth generation Raypex 6.

There was a significant difference of accuracy with G0 and G72, indicating that accuracy of apex locators decreases with increase in apical diameter. One of reason being the destruction of the apical constriction.

The literature suggests that the reason for the lower accuracy of EFLs in teeth with enlarged apical foramina may be the difficulty identifying the narrowest diameter of the canal with these devices.^{23, 24}

Vidya Saraswathi et al., said that the performance of EALs is affected by the absence of apical constriction.²⁵

In this study, snug fitting files were used for determination of working length. Manuela Herrera et al proved that the file size has to be adjusted to apical canal size for accurate measurements.¹²

One of the reasons that a radiographically determined WL lacks accuracy is that it is based on the radiographic apex rather than the apical foramen (the end of the canal).

WL is obtained with a radiograph by positioning the tip of a file at a certain distance (usually 1 mm) from the radiographic apex. However, WL should be based on the location of the AC rather than that of the radiographic apex because the apical foramen frequently is not at the radiographic apex in cases where it is eccentrically placed.

A research model was performed using alginate as an electroconductive medium. This model has been extensively used in the literature and has presented results that can be extrapolated to clinical conditions.

According to Sreeha Kaluva Kolanu et al, alginate is found to be the most stable material for correct estimation of working length since it is simple, inexpensive, and stable for hours.²²

To eliminate methodological biases, only mandibular premolars with a single root canal and with patent AFs were used.

Conclusion

The result of the present study revealed that Root ZX, Apex ID, Propex PIXI and Raypex 6 were 86%, 80%, 80% and 87% accurate respectively within ± 0.5 mm.

The results showed no statistically significant differences in accuracy and consistency between the four EALs.

But, there is significant difference between the accuracy of apex locators with different apical diameters.

Accuracy of all the apex locators decreases with increase in the apical diameter.

Raypex 6, newer generation apex locator performed best in present study.

Within the limitations of the study, it can be concluded that the electronic apex locators can be used, only as an adjunct to radiographs in determining the working length of teeth with wide apical diameters.

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