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Assessment of accuracy of three different generations of electronic apex locators in different environments of root canal system: An in vitro study

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Abstract

Background: Endodontic treatment encompasses cleaning, shaping, disinfection, and three-dimensional obturation of entire accurate length of root canal system. Hence, accurate determination of working length plays very important role for clinical success of endodontic treatment.

Objectives: To assess the accuracy of three different generations of electronic apex locators (EALs) in different environments of root canal system.

Methods: A descriptive cross-sectional study was done in 60 single-rooted mandibular premolars for three months from 2021/12/21 to 2021/03/18 at Kantipur Dental College. Non-carious teeth were collected (excluded if more than one canal) by convenience sampling after ethical clearance. Access opening with occlusal reduction of cusp tips were performed. Before, electronic measurement of root canal length, reference length: Actual Length (AL) was recorded. Samples were divided into four groups with different environment (I = dry canal; II = 3% NaOCl; III = 2% CHX; IV = blood plasma) with 15 samples each. Electronic measurements were obtained using all three EALs: Rootor (fourth generation), Propex Pixi (fifth generation), and Apex ID (sixth generation). Recorded AL was compared with value obtained with EALs and their differences were tabulated with Microsoft Excel.

Results: Accuracy in working length measurement by Rootor was 80%, 80%, 60%, 53.3%; Propex Pixi was 46.7%, 80%, 86.7%, and 100%; and Apex ID was 100%, 93.3%, 86.7%, 100% in Group I, Group II, Group III, and Group IV respectively of AL.

Conclusion: Accuracy of Rootor was high in dry canal, Propex Pixi in moist environment whereas, Apex ID in both dry canal and moist environment.

Key words: Apex locator; Root canal; Working length.

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INTRODUCTION

Accurate determination of the working length of root canal system is very important for clinical success of endodontic treatment.[1] Radiographs, tactile sense, anatomical knowledge, absorbent point, and electronic apex locator (EAL) can be used to determine working length. However, all the methods have limitations.[2,3] Radiographic technique, the most popular one,[4] is limited by being a two-dimensional imaging. Accuracy of radiographic technique depends on its quality[5] and it also causes exposure to harmful radiation.

Recently, EAL has emerged as a popular technique.[6-9] However, most practitioners still employ fourth and fifth generation EALs. The fourth generation locators do not work in exudate and blood whereas fifth generation locators do not perform very well in dry canal.[10] The

sixth generation EALs are expected to work accurately in moist (blood, exudates, irrigants, non-extirpated pulp) as well as dry canal.[10]

There are still no well documented studies that compare these three apex locators. The aim of this study was to assess the accuracy of sixth generation EAL (Apex ID) to determine working length of root canal in comparison with fourth (Rootor) and fifth generation (Propex Pixi) locators in simulated conditions with blood plasma, and irrigants: 3% sodium hypochlorite (NaOCl), 2% chlorhexidine (CHX).

METHODOLOGY

A descriptive cross-sectional in vitro study was done in 60 single-rooted non-carious mandibular premolar teeth with closed apex. The study was done for three months from 2021 December 21 to 2021 March 18 in the Department of Conservative Dentistry and Endodontics, Kantipur Dental College, Basundhara, Kathmandu, Nepal. The study proposal was approved by Institutional Review Committee (KDC-IRC, Ref. 38/020) on 2020 December 20.

Premolars were extracted either as a part of orthodontic treatment or due to perio-endo lesions. Premolars were chosen because of their easy availability as they are frequently extracted teeth during orthodontic treatment. The procedure was performed by a single operator, the first author. Sample size was calculated using the formula for comparison of means: $N= 2*(Z\alpha + Z\beta)^2 *SD^2/ d^2$; Where, m1=16.62, m2=18.62 , sd1=1.38, sd2=1.30).[11] Taking Power = 90%: $Z\alpha$ =1.96; $Z\beta$ = 1.282. The calculated size, N = 9.44 ≈ 10. Hence, total sample size = 10*4 = 40. Due to availability of premolars, 15 in each group resulting in a total of 60 (15*4) sample teeth were taken for study purpose .

All collected samples were immersed in 3% NaOCl solution (Septodent) for 24 hours to remove adhered tissues. Calculus and surface deposits were removed by ultrasonic scaler (DTE). All collected samples were examined under 5X magnification using magnifying loupes. Samples with root resorption, fractures were excluded. For each sample, two radiographs were taken in buccolingual and mesiodistal projection to view root canal anatomy and radiographic apex. Teeth with more than one canal were excluded. Finally, 60 were selected for the study. Then, access opening and occlusal reduction of cusp tips of the samples were performed using round bur. Before, electronic measurement of root canal length, stainless-steel (SS) number 15 K-file (MANI) was inserted into each canal until the tip became visible through the foramen. Then file was withdrawn until a magnification glass 5X showed its tip to lie tangential to apical foramen. The silicone stop was adjusted to level of chosen as reference for root canal measurement and a millimeter ruler was used to measure the distance from silicone stop to the file tip. This measurement was recorded as reference length (Actual Length, AL). Barbed broaches (MANI) were used to extirpate the pulp but no root canal instruments were used to avoid enlargement of root canal. Then samples were rooted up to cementoenamel junction in a plastic container containing freshly mixed alginate (Coltene). Adequate care was taken to keep the alginate models moist. Then samples were divided into four groups with 15 samples in each, here convenience sampling method was used. In Group I (n = 15), root canals of samples were kept dry by using absorbent paper (META Biomed). In Group II (n = 15), the root canals of samples were filled with 3% NaOCl (Septodent). In Group III (n =15), the root canals of samples were filled with 2% Chlorhexidine (PREVEST DenPro). In Group IV (n=15), the root canals of samples were filled with human blood plasma mixed with Ethylene Diamine Tetraacetic Acid (EDTA) (META Biomed) as an anticoagulant.

Then, Stainless-steel (SS) number 15 K-file (MANI) was inserted within the root canal of sample and clip to the apex locator and circuit was completed by inserting the lip electrode into the alginate model. Electronic measurements were obtained by using all the three electronic apex locators- Rootor (META Biomed) fourth generation, Propex Pixi (Densply) fifth generation, and Apex ID (Sybron) sixth generation. The accuracy was measured by calculating the percentage of reading measured by that particular EAL that fell within the AL. The procedure was repeated three times for each tooth. The mean value was calculated and recorded for each sample. The recorded AL was compared with the values obtained with the electronic apex locators and their differences were tabulated and data were presented by using the bar diagram and tabular form by using Microsoft Excel 2013.

RESULTS

The results of this study showed that the accuracy in working length measurement by fourth generation EAL (Rootor) was 80%, 80%, 60%, 53.3%; fifth generation EAL (Propex Pixi) was 46.7%, 80%, 86.7% and 100%; and Apex ID was 100%, 93.3%, 86.7%, 100% in Group I, Group II, Group III, and Group IV respectively of AL (Figure 1).

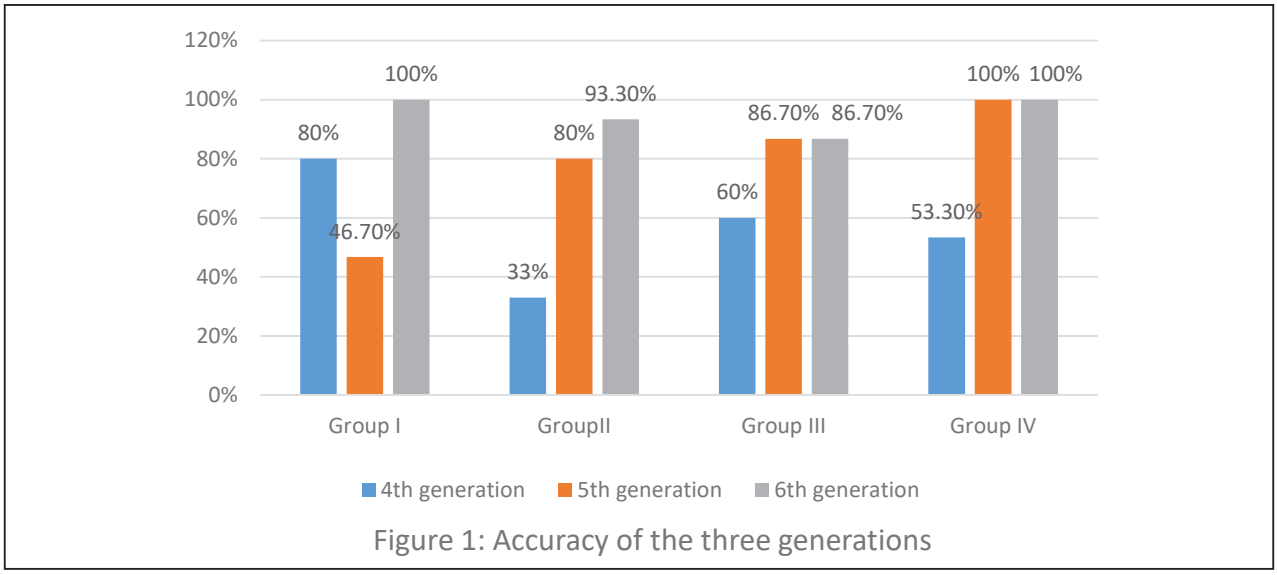

Figure 1: Bar diagram showing accuracy of three generations of EAL
(Group I: Dry Canal; Group II: 3% NaOCl; Group III: 2% CHX; Group IV: Blood Plasma. The fourth generation EAL: Rootor (META Biomed); fifth generation EAL: Propex Pixi (Densply); sixth generation EAL: Apex ID (Sybron)).

Table 1: Canal length measured with different electronic apex locators

EAL generation	Group I	Group II	Group III	Group IV
Fourth	0.03 ± 0.228	0.43 ± 0.372	0.20 ± 0.96	0.27 ± 0.32
Fifth	0.17 ± 0.408	0.10 ± 0.207	0.23 ± 1.04	-
Sixth	-	**0.03 ± 0.129**	**0.30 ± 1.03**	-

Table 2: Actual length and length determined by apex locators of root canal

		Mean ± SD	Std. Error Mean
Group I (dry)	AL	22.63 ± 1.38	0.3567
	Fourth	22.60 ± 1.29	0.335
	Fifth	22.47± 1.45	0.37
	Sixth	22.63 ± 1.38	0.3567
Group II (NaOCl)	AL	23.23 ± 1.12	0.288
	Fourth	22.83 ± 1.029	0.266
	Fifth	23.17 ± 1.175	0.30
	Sixth	23.23 ± 1.15	0.296
Group III (Chlorhexidine)	AL	21.27 ± 1.59	0.41
	Fourth	21.07 ± 1.47	0.381
	Fifth	21.03 ± 1.597	0.41
	Sixth	20.97 ± 1.64	0.423
Group IV (Blood)	AL	22.23 ± 0.94	0.24
	Fourth	21.97 ± 1.026	0.265
	Fifth	22.23 ± 0.94	0.24
	Sixth	22.23 ± 0.40	0.24

DISCUSSION

Rootor Apex locator (Meta Biomed) is a fourth generation electronic apex locator with multiple frequency technique to determine apical foramen. Propex Pixi (Dentsply Sirona and Maillefer) is a fifth generation electronic apex locator that uses multi frequency technology to locate apical foramen with great precision under wide range of canal conditions in root canal length.[11] The sixth generation electronic apex locator Apex ID (Sybron Endo) are based on dual frequencies that sent from and returned to the unit after travelling along the electric circuit.

The prognosis of endodontic treatment totally depends upon localisation of all canals, accurate working length determination, cleaning and shaping as well as three dimensional obturation of root canal system.[12] Among them, an accurate assessment of working length plays important key roles in determining the prognosis of an endodontic treatment.[12-14] In clinical practice, radiographic technique for determination of working length of root canal are not accepted for prognosis of endodontic treatment as it is 2-dimensional image of three-dimensional object. So, along with this technique, EALs are also used extensively. Therefore, the purpose of this in vitro study was to assess the accuracy of fourth generation EAL (Rootor), fifth generation EAL (Propex Pixi), and sixth generation EAL (Apex ID) in determining the working length in four different clinical simulated conditions- dry canal, 3% NaOCl, 2% Chlorhexidine and blood plasma.

In this Study, flattening of the cusp was done on selected sixty single-rooted mandibular premolar teeth to obtain a stable and reproducible reference point for file length measurement. This technique was also considered in study of Taneja et al.[15]

Many studies have documented that various materials such as agar, gelatin, saline solution, and alginate can be used as electro-conductive in nature for an in vitro study of EALs[16-18] that mimic the electrical characteristics of human tissues. In this study, the selected teeth were embedded in alginate model to electronically measure and simulate the clinical conditions because it mimics electrical impedance of human periodontium, stability, and firm consistency.[20,21]

There are different methodologies to establish Actual Length (AL). Some authors Martinez-Lozane et al.,[7] Mente et al.[22] had used radiographic technique for root canal measurements as control but, Lucena et al.[1] mentioned that, this methodology had some limitations. According to El Ayouty et al.,[23,24] and Kauffman et al.,[25] the reliable and usual methodology to establish AL in vitro study was to use the distance from reference plane to the apical foramen as control (minor apical diameter) as control. The apical constriction or minor apical diameter is located 0.5 mm from the major apical foramen and is the ideal and recommended end-point for instrumentation and canal filling.[4]

In this study also the methodology by El Ayouty et al[23,24] and Kauffman et al.[25] was followed. Stainless Steel (SS) number 15 K file was inserted into root canal of selected tooth until the tip to lie tangential to apical foramen and then silicone stop was adjusted to level of chosen reference point and distance from silicone stop to file tip was measured.

In this in vitro study, stainless-steel (SS) file was used for testing purposes because many studies on apex locator had been performed and generally they used only stainless-steel (SS) hand files for testing purposes.[26] However, comparison of accuracy in determining the length with an Electronic apex locator using stainless-steel (SS) and Nickel-Titanium (NiTi) seems clinically relevant.[27] But, still there are no sufficient research documentations on comparison between the accuracy of EALs using SS and NiTi hand files. So, further more studies might be required on comparison between SS and NiTi hand files for evaluation of accuracy on EALs.

In this study, the result of sixth generation EAL Sybron's Apex ID on dry canal was 100% which was almost similar to result reported (93%) by Gabriela et al.[28] However, in same dry canal condition, the fourth generation EAL META Biomed's Rootor reported 80% which showed higher accuracy than reading obtain from fifth generation Densply Propex Pixi. In previous study, author Altunbas et al.[29] also obtained most accurate reading in detecting perforation in dry canal than in wet conditions using Rootor EAL.

Reading of Apex ID in 3% NaOCl was 93.3% which was almost similar to finding of earlier study of 97.5% accuracy using NaOCl as an irrigant by De Camargo et al.[30]

In 3% NaOCl and CHX, Rootor showed less accuracy than Propex Pixi's findings 80% and 86.70% respectively where, Apex ID also showed same reading as Propex Pixi in CHX that means Rootor EAL is inefficient to give accuracy than Apex ID and Propex Pixi in NaOCl and CHX as root canal irrigation solution.

In blood plasma condition, both Apex ID and Propex Pixi showed same reading 100% accuracy whereas, Rootor Showed only 53.30% accuracy. That means, statistically both Apex ID and Propex Pixi EALs were significant to Rootor EAL and these findings of accuracy were also similar with findings reported by Taneja et al.[15]

In this study, sixth generation Sybron's Apex ID had showed less difference between actual length (AL) and length obtained by using Electronic apex locator followed by fifth and fourth generation EALs which was in accordance to studies conducted by Taneja et al.[15]

Most of previous studies had only used dry media or blood plasma and sodium hypochlorite for evaluation of accuracy of EALs but this present study includes comparison on accuracy of fourth generation META Rootor, fifth generation Densply Propex Pixi and sixth generation Sybron's Apex ID EALs in dry medium and wet environment like - 3% NaOCl, blood plasma and even 2% CHX which is frequently used as root canal irrigation solution nowadays. Thus, this study provides broader scope of research on the most common environment that is encountered during root canal treatment to find the accuracy of different generation electronic apex locators.

However, this study was done in extracted tooth so this study does not give idea about variation that might have been seen due to presence or absence of vitality of the teeth, age, and gender of patient. This in vitro study cannot be a true representative of clinical situations in which the whole treatment is done in the mouth.

CONCLUSION

The fourth generation EAL (Rootor) showed high accuracy in dry canal but poor accuracy in moist environment (3% NaOCl, 2% CHX, and blood plasma) in comparison to fifth generation EAL (Propex Pixi). Whereas, fifth generation EAL (Propex Pixi) showed higher accuracy in blood plasma followed by accuracy in 2% CHX , 3% NaOCl, and then in Dry canal, whereas, sixth generation EAL (Apex ID) showed highest accuracy in dry canal, 3% NaOCl, 2% CHX, and blood plasma respectively. So, the sixth generation EAL (Apex ID) showed the highest accuracy in both dry canal and moist environment like 3% NaOCl, 2% CHX, and blood plasma than the fourth and fifth generation EALs.

Further research is required to evaluate the accuracy of these apex locators in different clinical conditions and different properties of material of hand files.

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