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AN IN VITRO EVALUATION OF ACCURACY OF TWO ELECTRONIC APEX LOCATORS TO DETERMINE WORKING LENGTH IN PRESENCE OF VARIOUS IRRIGANTS

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ABSTRACT:

Aim : The present study was conducted to compare the accuracy of Root ZX and i-Root apex locator for determining working length in presence of different irrigating solution.

Methods: Eighty extracted single rooted human teeth were used. Teeth were sectioned at Cemento Enamel Junction(CEJ) and actual canal length determined. Then working length measurements were obtained using Root ZX and i-Root apex locator in presence of irrigating solutions namely 0.9% saline, 3% of sodium hypochlorite (NaOCl), 2% chlorhexidine digluconate(CHX) and 17% Ethylene Diamine Tetra Acetic acid (EDTA). The measurements obtained with Root ZX and i-Root apex locator were compared with actual canal length and subjected to statistical analysis using Post Hoc Test Tukey's Method.

Results: The present study revealed that both the tested Electronic apex locators (EAL) were able to measure the canal length in presence of tested irrigating solutions. The presence of irrigating solution saline, NaOCl, chlorhexidine, and EDTA in the root canal marginally influenced the accuracy of the Root ZX or i-Root ($P < 0.36$), but with no clinical significance.

Conclusion: The content of the root canal did not influence the accuracy while measuring working length using Electronic apex locators (EAL)

Key words: chlorhexidine, Root ZX, i–Root Apex locator, sodium hypochlorite, saline.

INTRODUCTION:

Preparation of canal, especially in the apical segment, without weakening the remaining dentin or perforating the root is essential for proper disinfection. To achieve this, virtually all steps of root canal therapy demand strict working length to ensure that neither the root canal system nor the periodontal ligament is damaged [1].

Establishing the working length at the apical constriction is considered ideal for endodontic treatment. The apical constriction (minor apical diameter) is the narrowest apical portion of the root canal with variety of morphological variations.[2] Electronic apex locators for assessing the root canal length have gained popularity for over 35 years, and

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these devices eliminate many of the problems associated with radiographic measurements.[3]

Sunada introduced principle of 'biological characteristics theory' to clinical practice. Based on this research, Sunada demonstrated that a constant resistance value of 6.2kΩ is established between the mucous membrane and periodontium irrespective of age, sex, tooth, canal curvature of the patient][4].The third-generation or multiple frequency-dependent apex locators use alternate current, with difference of impedance (Eg Endex) or ratio of impedance (Eg.Root ZX) between electrodes depending on the signal frequencies used[5].

The Root ZX (J. Morita Corp. Kyoto, Japan) uses two different frequencies (8 kHz and 0.4 kHz) to simultaneously measure the impedances in the canal[6]. The device determines a quotient value by dividing the 8 kHz impedance value by the 0.4 kHz impedance value. The minor diameter is located when the quotient equals 0.67. By using two frequencies, the Root ZX can be used in all types of fluids because the quotient **(0.67)** is always the same[7]

i-Root (S-Denti Co. Ltd Seoul, Korea) apex locator has different frequencies 5 KHz and 500 Hz. The manufacturer claims that its accuracy is good, irrespective of canal contents.

This study was conducted to test the accuracy of two frequency based apex locators namely Root **ZX** and **i-Root** in presence of these commonly used irrigants to find out whether the presence of irrigants affected the device measurement readings.

MATERIALS AND METHOD:

this invitro study was conducted after university ethical commtiee approval.

Eigthy single-rooted human permanent teeth without caries that were extracted for periodontal reasons were selected for this study. The teeth were cleaned of calculus, soft tissues, and debris with hand instruments. Teeth were kept in 0.2% sodium azide solution until use.

Preparation of samples

Standard access preparations was prepared and the occlusal edges were flattened for reproducible reference point. The crown of each tooth was sectioned at the cemento--enamel junction using a diamond disk (DFS -- Diamon GmbH Landenstraße, Riebenburg, Germany), revolving at a conventional speed in order to simplify access to the root canal and establish a level surface to serve as a stable reference for all measurements [8] Coronal Preflaring was accomplished using#4, #3, and #2 (Mani Inc., Japan) and Pulp extirpated with a barbed broach (Spirocolorinox, Dentsply).

Measurement of actual working length

The actual lengths (AL) were determined Using a #10 file into the canal until the tip of the file was just visible at the apex using X 2.5 magnification measured

using digital callipers (Mitutoyo Co., Japan).The actual working length was established by subtracting 0.5 mm from this measured length. The actual length readings were compared to electronic working length readings. Apical instrumentation was completed to a #20 (ISO) Flex- R file. The canals were then irrigated with 20 ml of distilled water using 26 gauge irrigating syringe.

Working model for electronic working length determination

Three plastic rectangular boxes, 15 × 3 × 4 cm in dimension were used for preparing this model. Ten teeth among the selected samples were glued to a plastic frame using modeling wax. Alginate was poured into the box, and the frame with the teeth was embedded into the alginate. In order to complete the electrical circuit of the apex locator, the labial clip was fixed to the edge of the plastic box and immersed in alginate. All the measurements were made within 2 hrs of the model being prepared.

Electronic Length (EL) measurements: this was carried out using four irrigants in the root canals;

- 0.9% Saline, (Claris life sciences Ltd,India)
- 3% Sodium hypochlorite (vishal Dentocare,India)
- 2% Chlorhexidine digluconate (Bombay dental surgicals Pvt Ltd,India)
- 17% EDTA liquid. (Bombay dental surgicals Pvt Ltd,India)

Total Care was taken to ensure that all the circuits, batteries, and the operating modes of both apex locators are fully functional during study procedure.

At first, canals were irrigated with 3% Sodium Hypochlorite using 26 gauge beveled needle in 2 ml syringe (Unolok, Hindustan Syringes and Medical Devices Ltd, India). The pulp chamber was then gently dried with an air syringe and cotton pellets were used to dry the tooth surface and eliminate excess irrigating solution. A 15 K-file (Mani, Tochigi, Japan) with the file clip of the apex locator was attached to the file and inserted inside the canal until the apex locator showed the "apex" reading. The file was slightly pulled out until the apex locator showed the "0.5 mm" reading. The silicone stop was adjusted, the file was removed and the distance between the base of silicone stop and file tip was measured using digital caliper(Mitutoyo Co., Japan) to the nearest 0.5 mm; 0.5 mm was subtracted from this length and recorded as Actual Length(AL).

Electronic Measurements were considered as valid if they were stable for at least 5 seconds. The recorded values were tabulated.

The Electronic Length Measurements of 40 teeth with Root ZX were recorded followed by 40 teeth using i – Root apex locator. The “apex” as indicated by both devices was chosen as the apical reference. Measurements were repeated three times and the average was computed. For each irrigant 20

teeth were used, that is 10 teeth for each apex locator.

Electronic length measurements were recorded using Root ZX followed by i-Root. For every irrigant the order was reversed. Each measurement was repeated three times and the average was calculated and computed. To prevent cross contamination, each set of 2 measurements was conducted in a fresh mixture of alginate.

Between testing, teeth were irrigated with distilled water and dried with paper points.

Results were subjected to statistical analysis .

RESULTS:

Compilation of statistical analysis were done. **Table 1** shows Mean and standard deviation distances between the apical constriction and the instrument tip with respect to actual length and electronic length measured using both electronic apex locators in presence of four different irrigating solutions.

Table 2 indicates that the distance of the instrument tip from the apical constriction in both the apex locators were not significant. However the electronic measurements of both devices were shorter than the actual length in an average range between 0.51 (0.15SE) and 1.31 (0.17SE). But only for Chlorhexidine the measurements were slightly deviated from Actual Length but it was not clinically significant. The presence of irrigating solution like saline, NaOCl, chlorhexidine, and EDTA in the canal had no significant effect on the accuracy of the Root ZX or i-Root ($P < 0.36$).

However using multiple comparision (Tukey HSD test) mesurments of both apex locators in relation to Actual Length AL showed that measurement made with saline and its comparision with chlorhexidine (CHX) and EDTA showed a P value of < 0.05

DISCUSSION:

Apical constriction (minor diameter) may vary widely in shape, it is generally the narrowest portion of the root canal which has the smallest diameter of blood supply, thus creating the smallest wound site and providing the best healing conditions.[4]

Cemento-dentinal-junction (CDJ), the point where the pulp tissue changes into periodontal tissue, is the most ideal physiologic apical limit of working length. However CDJ is highly irregular and can be upto 3 mm higher on one wall of the root compared with the opposite wall. And its relationship with minor constriction also varies. However, the CDJ and apical constriction do not always coincide, particularly in senile teeth where cementum deposition occurs continuously. This alters the position of the minor diameter.[7]

In this invitro study two modern electronic apex locators namely Root ZX and i-Root were used to calculate the working length of the root canal.

This in vitro study was designed to allow easy determination of the actual tooth length. The media used in mounting models need to have similar electrical resistance to periodontal tissue to allow for accurate data collection. Alginate has been described as the ideal embedding medium because its relatively firm consistency prevents intrusion of material into the apical foramen and resists force exerted by mechanical movement of the file, allowing the operator to accurately determine working length.[8] .[9]

The main disadvantage was in its limited working time because the alginate tended to desiccate unless kept in a moist environment. In the present study, all measurements were made within 2 hours of the model being prepared in order to ensure the alginate was kept sufficiently humid. The alginate model used in this study was accurate, easy to assemble, and cost-effective

To evaluate the accuracy of EALs, the ±0.5 mm range from AL was chosen, which is considered clinically acceptable and highly accurate.[10]

Results of the present study showed that the evaluated irrigant did not have any effect on the accuracy of the Root ZX and i –Root.[11] This is in accordance with results of study by Kang JA & Kim SK [12] Sakkir N et al [13] and Niranjan [14] et al Root ZX and i-root apex locators were also tested along with other apex locators.

Kang JA & Kim SK [12]evaluated accuracies of seven different apex locators under various conditions.EALs used were Apex Finder 7005, Apit, Bingo-1020, i-Root , ProPex, Root ZX, and SmarPex. The measurements were taken when the canal were dry, and saturated sequentially with 5.25% NaOCl, saline, 0.1% chlorhexidine, and 15% EDTA. All these tested EALs were reliable in the presence of five root canal irrigants.

Sakkir N et al [13] in their study revealed that no statistically significant differences were found amongst the five apex locators (Root ZX II, i-Root, Endo Master, Triauto ZX, and Elements apex locator) and the actual working length of the teeth evaluated. The large majority of EAL measurements were within the ± 0.5 mm of the actual length for all the five electronic apex locators. The average values of all groups indicated that; all the apex locators tested in this study can accurately determine the root canal length with the Root ZX II, Triauto ZX and i-Root apex locator readings being the closest to the actual root canal length.

Niranjan [14] et al did an in vitro evaluation of the efficacy of five apex locators namely Root zx, Propex, Dentaport ZX ,i –Root and Reypex 5.All these modern apex locators gave comparable results in comparison to actual working length. However Root zx and i-Root were the most precise, followed by Dentaport zx, Raypex 5 and Propex

Carvalho et al [15] compared the accuracy of three electronic apex locators (EALs) - Elements Diagnostic®, Root ZX® and Apex DSP® - in the presence of different irrigating solutions (0.9% saline solution and 1% sodium hypochlorite). He concluded that Elements Diagnostic® and Root ZX ® apex locators were able to locate the cementum-dentine junction more precisely than Apex DSP®. Moreover, the presence of irrigating solutions does not interfere with the performance of the EALs.

Saru jain[16] compared the efficacy o f Root ZX & Propex II electronic apex locators after cleansing and shaping of the root canals and whether there was any alteration in accuracy when used in the presence of 1% NaOCl, LA Solution and 2% CHX. chlorhexidine digluconate as an irrigant matched more precisely with the actual canal length measurements

Dinapadu SJ et al [17] In their invitro study checked Root ZX II accurate in the presence of 3% NaOCl and 17% EDTA when measured with smaller and larger files. The results showed that Root Zx II was accurate in the presence of saline and 2% CHX when larger files were used.

Paras Mul [18] et al designed invitro study to compare the accuracy of Root ZX and SybronEndo Mini, in the presence of 0.9% saline; 1% sodium hypochlorite (NaOCl); 2% chlorhexidine digluconate (CHX), and 17% EDTA solution EL measurements were shorter with 1% NaOCl, whereas longer with 2% CHX for both the devices. Sybron Mini was more accurate using 1% NaOCl and 2% CHX than Root ZX,when the measurements were compared.

In present study, with both apex locators, Saline and EDTA gave the results close to the actual length. Thus, these irrigants can be considered as reliable solutions for electronic measurements. Large deviation occurred with the more conductive solution such as NaOCl and Chlorhexidine digluconate. But 2% Chlorhexidine digluconate showed largest deviation but clinically not significant. This is in agreement with study by Paras Mul [18] et al.

Chlorhexidine digluconate is an antiseptic and has an affinity to hydroxyapatite.[11] So its use should be carefully monitored when indication of chlorhexidine is necessary for the treatment of apical areas of the root canal.

The use of irrigating solutions is an important aspect of endodontic treatment. The irrigants investigated were: 3% NaOCl, with tissue solvent and antibacterial activity; 2% CHX with antibacterial activity even effective against Enterococcus faecalis; 17% EDTA, a chelator which facilitates canal preparation and removes the smear layer; and 0.9% saline with only flushing action served as a control. [11]

Thus 3 % NaOCl was used in this study because other in vitro studies [19] indicate that the accuracy of EALs is not significantly influenced by different concentrations of NaOCl [19]

CONCLUSION :

Within the limitations of this study Root ZX and i-Root can be considered to be an accurate electronic apex locators across a variety of irrigants commonly used in the practice of endodontics for measurement of the length of the root canal.

The contents of the root canal influenced the results of the measurements with both the EALs, but the differences were not statistically significant.

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TABLES:

	Media	N	Mean	Standard Deviation(SD)	Standard Error (SE)
AL	Saline	20	21.03	1.57	0.35
	NaOCl	20	19.75	2.38	0.53
	Chlorhexidine	20	19.55	1.82	0.40
	EDTA	20	19.4	1.18	0.26
EL of Root ZX	Saline	20	20.52	1.60	0.35
	NaOCl	20	19.27	2.02	0.45
	Chlorhexidine	20	18.24	1.62	0.36
	EDTA	20	18.78	1.31	0.29
EL of i-Root	Saline	20	20.76	1.53	0.34
	NaOCl	20	19.14	2.19	0.49
	Chlorhexidine	20	18.53	1.81	0.40
	EDTA	20	18.62	1.17	0.26

Table 1:Comparison between the AL (Actual Length) and the EL (Electronic Length) obtained by each EAL in the presence of the four irrigants (Post Hoc Test Tukey's Method).

	Root ZX (SE)	i- Root (SE)	t- value	p-value
Saline	0.51(0.15)	0.27(0.11)	1.86	0.17NS
NaOCl	0.48(0.10)	0.61(0.10)	1.11	0.27NS
Chlorhexidine	1.31(0.17)	1.02(0.19)	1.12	0.26NS
EDTA	0.62(0.15)	0.72(0.15)	0.70	0.48NS

Table 2: Mean Differences between AL (Actual Length) and EL(Electronic Length) measured by Root ZX & i- Root using the four irrigating solutions

	Media		Mean Difference (I-J)	Std. Error	p-value
Actual Length (AL)	Saline	NaOCL	0.88	0.56	0.410
		CHX	1.48	0.56	0.052
		EDTA	1.63(*)	0.56	0.026
	NaOCL	CHX	0.60	0.56	0.717
		EDTA	0.75	0.56	0.553
	CHX	EDTA	0.15	0.56	0.994
Root-ZX Apex locator	**Saline**	NaOCL	1.20	0.52	0.108
		CHX	**2.27(*)**	**0.52**	**0.000**
		EDTA	**1.73(*)**	**0.52**	**0.008**
	NaOCL	CHX	1.06	0.52	0.187
		EDTA	0.53	0.52	0.744
	CHX	EDTA	-0.53	0.52	0.740
i-Root Apex locator	**Saline**	NaOCL	1.01	0.54	0.252
		CHX	**1.62(*)**	**0.54**	**0.020**
		EDTA	**1.53(*)**	**0.54**	**0.030**
	NaOCL	CHX	0.61	0.54	0.678
		EDTA	0.52	0.54	0.772
	CHX	EDTA	-0.08	0.54	0.999

Table 3. **Multiple Comparisions: (Tukey HSD Test**)