EVALUATION OF I -ROOT APEX LOCATOR IN THE ABSENCE AND PRESENCE OF VARIOUS IRRIGANTS : AN EX-VIVO STUDY

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ABSTRACT

Introduction: The present study evaluates the accuracy of i-Root apex locator to determine the working length in presence of irrigants like Sodium hypochlorite (NaOCl), ethylenediaminetetraacetic acid (EDTA), Chlorhexidine (CHX) and in dry canal.

Methododolgy: Twenty single rooted premolars were selected. Working length measurement was done using electronic apex locator(i-Root) and then compared with the actual working length. Measurements using i-Root were taken after the canals were irrigated with 5ml of 3% NaOCl, 17% EDTA, and 2% CHX respectively. After the extraction of teeth, actual working length was determined using 10 k-file .The comparison was done with electronic measurement of all experimental groups by using analysis of variance (ANOVA).

Results: The statistical analysis revealed no significant differences in the accuracy of the i-Root apex locator and the actual working length in all the selected groups. The results reveal that the accuracy of i-Root apex locator was 80% with group A **(3% NaOCl)** in the range of ± 0.5 mm, the accuracy was 85% with **group B (17% EDTA)** in the range of ±0.5 mm; the accuracy was 80% with **group C (2% CHX)** in the range of ±0.5 mm; the accuracy was 100% with **group D (Dry group)** in the range of ±0.05 mm.

Conclusion: i-Root works equally well both in wet and dry canals

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INTRODUCTION

Accurate working length determination is a prerequisite for successful root canal treatment, thereby reducing the chances of insufficient cleaning of the canal or damaging periapical tissues from over instrumentation.(1)

Studies have shown that the apical foramen is not always located at the anatomic apex. The deviation between the apical foramen and root tip may be between 0 and 3 mm and occur in 50–98% roots. (2,3) These factors increase the inaccuracy and discrepancy of radiographic canal length determination.

Traditionally, the periapical radiographs has been the primary method of canal length determination, but there are certain technical limitations associated with this approach. Radiographs are two dimensional images of a three dimensional object that do not consistently reveal the root canal portals of exit.(2,4)

To overcome the drawbacks of radiography, the electronic apex locator (EAL) was designed and marketed to determine the terminus of the root canal objectively and accurately. Electronic apex locators have been widely used in endodontics to determine the root length during root canal treatment. In 1962 Sunada reported that when the tip of an endodontic instrument had reached the periodontal membrane through 'apical foramen', the electrical resistance between the instrument and the oral mucous membrane was a constant value of 6.5 KΩ. The major disadvantage with initially introduced Resistance and Impedance based devices, despite considerable developments over the years, was inaccurate and erroneous readings in root canal that contain moisture, vital pulp tissue, blood and other exudates or remnants of intracanal irrigants. (5,6,7) The importance of the irrigating solution in endodontic treatment is well documented. During and after instrumentation, the irrigants facilitate removal of microorganisms, tissue remnants, and dentin chips from the root canal through a flushing mechanism. Sodium hypochlorite (NaOCl), ethylenediaminetetraacetic acid

(EDTA), Chlorhexidine (CHX) has been most widely used in dentistry. NaOCl has tissue dissolving activity; EDTA is used for its chelating activity. Chlorhexidine digluconate (CHX) is widely used in disinfection in endodontics because of its good antimicrobial activity. The electroconductivity of these solutions have been thought to affect the results of the electronic working length measurements.[8] A limited number of in vivo studies have evaluated the accuracy of electronic apex locators in the presence of different irrigants. (9,10) The true effect of various solutions is still debatable.

A Newly designed apex locator 'i-Root' (Denti, Seoul, Korea)is a fifth generation apex locator where micro signals consisting of dual frequency(0.5 and 5 kHz) coming from the main unit return to where they are sent after travelling along the electric circuit attached with innovative 2-D graphical patient management software which displays the difference into a distance value on the LCD of the computer. According to manufacturer's i-Root works accurately in wet canals with blood, tissue, NaOCl, EDTA, 2% CHX etc.

The purpose of this Ex vivo study was to evaluate and compare the efficacy of the i-Root in determining the working length in presence of 3% NaOCl, 17% EDTA, 2% CHX and in Dry canal

MATERIALS AND METHODS

Preoperative intraoral periapical radiographs were taken for mandibular premolars scheduled for extraction in orthodontic patients. 20 vital single rooted mandibular premolars with mature apices were selected. Teeth having metallic restorations, caries, root resorption, periapical lesion, fractures, open apices were excluded. A written consent from the patient and clearance from the ethical committe was obtained.

After administration of local anesthesia and isolation with rubber dam, the straight line access to the root canal was established with no.2 round bur (Mani,INC.Japan) using high speed handpiece (NSK, Japan) under water coolant. Canal orifice was located with endodontic explorer and coronal portion of each canal was flared till Gates Glidden drills #3 (Mani,INC.Japan). Contents of canal were removed with barbed broach (Mani,INC.Japan). In each tooth, electronic measurements were recorded in the presence of three different irrigants as well as in dry condition and were grouped as follows:

Group A – 3 %NaOCl , Group B - 17% EDTA, Group C - 2% CHX , Group D - Dry group

Measurements using i-Root were taken after the canals were irrigated with 5ml of 3% NaOCl, 17% EDTA, and 2% CHX respectively with syringe and a 30- gauge needle. In between the experimental solutions, saline was used to irrigate the canals. Excess fluid was removed, but no attempts were made to dry the canal. The last measurement was taken in completely dry canal.

i-Root was used according to manufacturer's instructions. The clip was attached to patient's lip and stainless steel size 15 k-file was connected to the file holder of the electronic apex locator .Then the file was advanced slowly within the canal until the visual reading shows the position of the file tip at designated target (minor foramen) as shown in LCD panel of apex locator and attached LCD of the computer .Working length was determined with electronic apex locator and then compared with the actual working length

For measurement of actual working length, teeth were extracted immediately and washed with distilled water and immersed in 3%NaOCl for 10 minutes for the removal of any residual soft tissue and numbered 1 to 20. Then a size 10 k-file (Mani,INC.Japan) was inserted till the tip of the file is visible through the major foramen under the magnifying loupe (2.5x magnification). Then 0.5mm was subtracted from the measurements and recorded as Actual Working Length.[11] Positive values indicated the measurements that exceeded the actual working length (long measurements), whereas negative values indicated measurements that were short of actual working length.

Actual working length was compared with electronic measurements of all experimental groups by using analysis of variance (ANOVA). Significance was set at $P < .05$.

RESULTS

All the groups showed slight deviations from actual canal

Table 1: mean value of actual length and electronic canal length in various canal condition

Samples	N (No. of samples)	Reading of Apex Locator	
		Mean	Std Deviation
Actual length	20	21.1500	1.63111
Group A (3% NaOCl)	20	20.9750	1.62606
Group B (17% EDTA)	20	21.0000	1.72444
Group C (2% CHX)	20	21.4250	1.53276
Group D (Dry group)	20	21.0750	1.61632
P value ANOVA Test			0.055, NS

Table 2: mean value of deviations from actual canal length

Groups	N	Deviations from actual canal length	
		Mean	Std Deviation
Group A (17% NaOCl)	20	-.1750	.59105
Group B (17% EDTA)	20	-.1500	.43225
Group C (2% CHX)	20	.2750	.49934
Group D (Dry group)	20	-.0750	.18317
P value ANOVA Test			0.055, NS

length (Table 1 & 2). Group A, Group B, Group D gave short readings as compared to actual length whereas in Group C, the measurements were slightly long than the actual length.But statiscal analysis revealed no significant difference between the groups when compared with actual canal length (p value =0.055).

Table 3 shows the percentage accuracy of apex locator in various canal conditions when compared with actual length.

Readings of electronic length	No. of samples	Groups			
		Group A (3%NaOCl)	Group B (17% EDTA)	Group C (2%CHX)	Group D (Dry group)
1 mm short of Actual length	Count	2	2	0	0
	%	10.0%	10.0%	0.0%	0.0%
0.5 mm short of AL	Count	8	4	3	3
	%	40.0%	20.0%	15.0%	15.0%
Precisely at AL	Count	8	13	7	17
	%	40.0%	65.0%	35.0%	85.0%
0.5 mm over of AL	Count	0	0	6	0
	%	0.0%	0.0%	30.0%	0.0%
1 mm over of AL	Count	1	1	4	0
	%	5.0%	5.0%	20.0%	0.0%
1.5 mm over of AL	Count	1	0	0	0
	%	5.0%	0.0%	0.0%	0.0%
P value (Chi square test		<0.001			

The accuracy of i-Root apex locator was 80% with group A (3% NaOCl) in the range of ± 0.5 mm, the accuracy was 85% with group B (17% EDTA) in the range of ±0.5 mm; the accuracy was 80% with group C (2% CHX) in the range of ±0.5 mm; the accuracy was 100% with group D (Dry group) in the range of ±0.05 mm (Table 3) The statistical analysis revealed no significant differences in the accuracy of the i-Root apex locator in determination of actual canal length in all the selected groups.

DISCUSSION

Recently introduced frequency dependent apex locators are known to produce accurate readings in presence of canal fluid, but few studies have reported variable results in the presence of different irrigating solutions depending upon the electroconductivity. [8,9,12,13,14,15,16] NaOCl has been found to be highly electroconductive (66mS) with high alkaline pH of 11.72, followed by 17% EDTA(40mS, pH 7.01)and 2% CHX had poor electroconductivity (1mS, pH6.5). (14) However there is still a concern to whether the high electroconductive irrigants can affect the new generation EALs performance.

Thus the present study was an attempt to evaluate the efficacy of recently introduced i-Root apex locator in different canal

conditions. The percentage accuracy of i-Root apex locator in the range of ±0.5 mm was maximum in dry group. Accuracy in dry group can be explained on the basis of a study by Meredith & Gulabivala (17), who reported a clear increase in series resistance with increasing distance from the radiographic apex for dry canals (22.19–92.07 kΩ) and those figures were markedly higher than for those containing deionized water (9.32–12.10 kΩ) and sodium hypochlorite (7.46–8.92 kΩ). Measurement of changes in resistance was therefore easier in dry root canals and it is likely that this is why commercial EALs perform better in dry canals.

The results of present study showed insignificant difference between the irrigating solutions. The results are in accordance to few other studies who found that the presence of irrigating solution does not influence EAL measurements. Jenkins et al (18) evaluated the accuracy of Root ZX in presence of variety of endodontic irrigants i.e 2% lidocaine, 5.25% sodium hypochlorite, RC Prep, EDTA, 3% hydrogen peroxide and Peridex. Their results showed that Root ZX (dual frequency ratio based) reliably measured the canal length, regardless of irrigants. Similar results were obtained by few other studies who didn't find any difference of EAL in the presence of different electroconductive irrigants.(10,11,19)

Reason for irrigating solutions not influencing the EALs measurements can be explained on the basis of a study by Kobayashi & Suda (20) who explained that the dual frequency "ratio method" based apex locator promises to compensate for both reduction of the electrode impedance and increase in electrode capacitance when the strong electrolyte is in the canal which allows the apex locator to work accurately in all canal conditions.

However, the results of our study differed from few other studies in which EAL was affected by irrigating solutions (Fan et al 2006. , Ozsezer et al. 2007 ,Joshi & Ponnappa 2011, Mull etal. 2012). [6,8,13,14] It has been speculated that a solution with high electroconductivity tend to give short readings as compared to low conductive solutions which might affect the accuracy of EALs.

Fouad et al. (1993)(21) compared the accuracy of Endex with that of Exact-a-pex, sonoexplorer mark III and Neosono-D SE in presence of fluid (70% ethanol, 2% Xylocaine and 2.6% sodium hypochlorite) in the canal with variation in foramen size. They found that Endex was superior in more conductive fluids and wider apical foramen which could be accounted by its improved circuitry which presumably calibrates its measurements to the specific canal conditions. Similarly, in a study by Pilot and Pitts (1997)(22), the prediction error of EAL (sono explorer IV) was checked in the presence of different irrigants (RCprep,70% isopropyl alcohol,14.45% EDTA, normal saline and5.25% NaOCl). They found less prediction error in the presence of less electroconductive irrigant RC prep and in dry canal .Reason was explained on the basis of an insulating effect of RC prep between the canal walls ,tissue debris and file.,which allows for more consistent impedance change as the foramen is approached .Venturi& Breschi (2005)(9) in an invivo study compared two electronic apex locators (apex finder and Root ZX) at five different stages during root canal instrumentation and found that Apex Finder was negatively influenced by NaOCl in the root canal. The Root ZX was more frequently unable to reveal the stable measurements in low conductivity canals and was explained on the basis that the conducting solutions allow better electrical contact with apical tissues which changes the electrical characteristics. Thus change of impedance as the foramen approached is minimal. This minimal change would complicate the electrical determination of the foramen, because small changes may also occur as the result of other variables in the canal system. The greater impedance changes seen with the use of nonconducting irrigants and dry canal may also allow better prediction of file position in relation to the foramen.

Mull et al. (2012)(14) compared the accuracy of two electronic apex locators in the presence of various irrigants. The results showed that the most electroconductive solution 1%

NaOCl followed by 17% EDTA were shorter than actual length and the poor electroconductive solution like 2% CHX gave longer readings than actual length.

A possible explanation of variation in the results of different studies may be attributed to difference in the methodology, difference in the teeth anatomy, apex locators with difference in the mechanisms.

So, under the conditions and limitations of this ex vivo study, dual frequency (0.5 kHz and 5 kHz) "ratio based" i-Root apex locator performed equally well in absence and presence of different irrigants. The results of the present study therefore conclude that i-ROOT apex locator is able to locate cementodentinal junction precisely and accurately and the presence of irrigating solutions does not interfere with the performance of the EAL

CONCLUSION

It can be concluded that i-ROOT apex locator is able to locate cementodentinal junction precisely and accurately and the presence and absence of irrigating solutions does not interfere with the performance of the EAL. Electroconductivity of irrigating solutions had no influence on the accuracy of the modern apex locator.

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