

Comparative Evaluation of Accuracy of Two Electronic Apex Locators in the Presence of Contemporary Irrigants: An *In vitro* Study

Queentaj Baruah¹, Nidhi Sinha², Bijay Singh³, P. Narendranatha Reddy⁴, Kaveri Baruah¹, Vaishak Augustine¹

¹Department of Conservative Dentistry and Endodontics, Vyas Dental College and Hospital, Departments of ²Conservative Dentistry and Endodontics and ³Prosthodontics, Jodhpur Dental College General Hospital, Jodhpur, Rajasthan, ⁴Department of Oral Pathology, CKS Theja Institute of Dental Sciences, Tirupati, Andhra Pradesh, India

Received : 01-02-18.
Accepted : 25-03-18.
Published : 18-07-18.

INTRODUCTION

Endodontic therapy comprises many critical steps, and establishing working length is one of it. In recent years, electronic devices for assessing the root canal length are gaining popularity as they help in eliminating problems associated with radiographic measurements. Apex locators (electronic apex locator [EAL]) with dual- and multi-frequency technology have been frequently used in locating the apical foramen under varied canal condition. Accuracy of contemporary apex locator ranges from 82% to 96% within 0.5 mm. Root ZX Mini is a third-generation apex locator with a history of long clinical success, making it a gold standard among the apex locators.^[1] Propex II is a multifrequency-based, fifth-generation apex locator with a precision of 83%–91% in 0.5 mm range.^[1,2] The presence of irrigants further influences this accuracy

ABSTRACT

Aim: The present study was aimed to compare the accuracy of Root ZX Mini and Propex II in the presence of 0.1% octinidine dohydrochloride (OCT), 2% chlorhexidine gluconate (CHX), and 5% sodium hypochlorite (NaOCl) heated and nonheated before and after preparation.

Materials and Methods: Eighty extracted single-rooted teeth were selected for the study and decoronated. Teeth were mounted in an alginate model. Actual working length (AL) was measured using a stereomicroscope under ×4 magnification. Electronic working length measurements were recorded using Root ZX Mini and Propex II apex locators in the presence of 0.1% OCT, 2% CHX, and 5% NaOCl (nonheated and heated to 60°C) before and after preparation. Mean and standard deviation differences before and after preparation were calculated and statistically analyzed using analysis of variance and paired *t*-test.

Results: The accuracy of Root ZX Mini before and after preparation within ±0.5 mm of AL was consistently high in the presence of irrigants than Propex II. 5% NaOCl (heated and nonheated) showed more variation than the other irrigants, in the working length determination in both the apex locators.

Conclusion: Electronic length measurements were shorter with heated and nonheated 5% NaOCl and longer with 0.1% OCT and 2% CHX for both the electronic apex locators.

KEYWORDS: Heated 5% sodium hypochlorite, octinidine dohydrochloride, Propex II, root canal length measurements, Root ZX Mini

which is illustrated to be in the range of 75%–95% in various studies.^[3,4]

Chlorhexidine gluconate (CHX) is a commonly used irrigant with broad-spectrum antimicrobial activity, substantivity, and less toxicity. It is currently the irrigant of choice along with sodium hypochlorite (NaOCl). NaOCl is an endodontic irrigant with effective antimicrobial action and tissue-dissolving capability, but concerns have been raised regarding its toxicity to host tissue in higher concentrations. Previous studies have demonstrated that the toxicity can be reduced,

Address for correspondence: Dr. Nidhi Sinha, Preksha Dental Care and Implant Center, Preksha Hospital, Pal Road, Jodhpur - 342 001, Rajasthan, India.
E-mail: dr.nidhi.sinha@gmail.com

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

For reprints contact: reprints@medknow.com

How to cite this article: Baruah Q, Sinha N, Singh B, Reddy PN, Baruah K, Augustine V. Comparative evaluation of accuracy of two electronic apex locators in the presence of contemporary irrigants: An *in vitro* study. J Int Soc Prevent Communit Dent 2018;8:349-53.

Access this article online	
Quick Response Code: 	Website: www.jispcd.org DOI: 10.4103/jispcd.JISPCD_50_18

antimicrobial and tissue-dissolving capacity can be increased with an increase in temperature, but there is limited research in this aspect.^[5]

0.1% octinidine hydrochloride (OCT) is a newly introduced endodontic irrigant whose clinical properties and its effect on accuracy of apex locators are yet to be established. Furthermore, literature is sparse in regard to the efficacy of apex locators, Root ZX Mini and Propex II, in the presence of heated 5% NaOCl and the new irrigant 0.1% OCT.

The primary objective of this *in vitro* study was to evaluate the accuracy in working length determination of two EALs (Root ZX Mini and Propex II) in the presence of four contemporary irrigants (0.1% OCT, 2% CHX, and 5% NaOCl heated and nonheated). Furthermore, the secondary objective was to determine the effect of cleaning and shaping on the accuracy.

The null hypothesis tested were (a) both EALs produced similar results in the presence of same irrigants, (b) all irrigants had a similar effect on the accuracy of apex locators, and (c) canal cleaning and shaping had no effect on the accuracy of the apex locator.

MATERIALS AND METHODS

Eighty human permanent single-rooted teeth with mature apices scheduled for the extraction for periodontal and prosthetic reasons were selected after ethical clearance (Ref No. VDC&H /Principal/2018/E/798) for the study. The sample size was determined based on the level of significance and the power and effect size of the previous studies. Teeth with >30° curvature, external and internal resorption, calcified canals, endodontically treated teeth, and canal configuration other than type I configuration were excluded from the study. Teeth were visually inspected for cracks using a microscope of ×4 magnification. Teeth were placed in 5% NaOCl solution for 6 h to remove organic tissues. Calculus, soft tissues, and debris were removed from the root surface using periodontal scaling tips. This was followed by access opening of the teeth using high-speed diamond bur under water coolant, and pulp tissues were removed using a barbed broach taking care not to enlarge the canal. The crown of each tooth was sectioned at cemento-enamel junction using a diamond disc revolving at a conventional speed to have a level surface for a stable reference point. The actual root canal length was measured using a 10 size K file into the root canal until the file was just visible at the apical foramen under a stereomicroscope of ×4 magnification. A rubber stopper was placed till the reference level and was carefully adjusted to determine the actual working lengths (ALs). The distance between the file tip and stopper was measured using a digital

caliper to the nearest 0.1 mm and recorded. Subtraction of 0.5 mm was done from the actual length to determine the working lengths.

MOLD PREPARATION

For preparing the mold, freshly mixed alginate impression material was poured in a cold cure acrylic mold which acted as an electroconductive medium. The teeth were placed into the alginate material till the cemento-enamel junction. The readings were taken by placing the lip clip in the alginate and the file clip into the root canal.

In this study, 2% CHX, 5% NaOCl heated (60°C) and nonheated, and a recently introduced irrigant 0.1% OCT were used to determine the working length accuracy of two apex locators (Root ZX Mini and Propex II). Electronic working length measurements were taken using both the apex locators (Root ZX Mini and Propex II) for all the 80 teeth. The end point for Root ZX Mini was the point when “APEX” was displayed in the monitor of the apex locator in a continuous audible tone. Similarly, for Propex II, the end point was when the monitor in Propex II showed 0.0. Each apex locator group was further subdivided into four subgroups based on the different irrigants used as follows:

- Group A – 0.1% Octenidine dihydrochloride
- Group B – 2% CHX
- Group C – 5% NaOCl
- Group D – 5% NaOCl heated to 60°C.

The irrigants were introduced into the canal using a 23-gauge needle. This was followed by cleaning and shaping of the root canals till 30 size K file, and the electronic measurements were again taken to determine any variation in the accuracy of the electronic measurements in the presence of different irrigants.

The measurements were carried out by three different examiners with each apex locators, and the mean of the three measurements for all the teeth was taken for statistical analysis.

The measurements were recorded in millimeters. The difference between the electronic measurements and the actual lengths was calculated for each tooth in the presence of all the irrigants. The differences in the working lengths were charted and statistically analyzed using two-way analysis of variance (ANOVA) and paired *t*-test.

The data were collected with both the apex locators in the presence of these irrigants before and after preparation and were subjected to statistical analysis. The data were statistically analyzed using two-way ANOVA at 0.05 level of significance. Comparison of actual and electronic measurements before and after preparation of

the root canal in the presence of various irrigants was carried out with the help of paired *t*-test after verifying the correlation of the paired sample test.

RESULTS

Compared to the actual canal length, a difference in frequency of >0.5 mm was observed in both the apex locators [Table 1]. Both the apex locators displayed minimum variation before canal preparation with 0.1% OCT, i.e., Root Z × 12 out of 80 samples and Propex II 14 out of 80 samples [Table 1]. Maximum variation was seen in after preparation samples of 5% heated NaOCl, i.e., 58 out of 80 in Root ZX and 66 out of 80 in Propex II [Table 1]. In general, more variation

was seen in after preparation samples (152 and 184, Root ZX and Propex II, respectively) in comparison to before preparation samples (118 and 154, Root ZX and Propex II, respectively) in both the apex locators [Table 1]. However, there were no statistically significant differences before and after preparation, in either of the apex locators. Table 2 represents the mean difference between the actual length and the electronic length ascertained by Root ZX Mini and Propex II in the presence of various irrigants in the root canal (in mm) before and after preparation. 0.1% OCT and 2% CHX showed consistently higher readings (indicated by + in mean), and 5% NaOCl heated and nonheated showed lower readings (indicated by – in mean) in both the apex locators. In comparisons to the four irrigants used, heated 5% NaOCl displayed more variation in both the apex locators.

Table 1: Frequency of differences of more than 0.5mm (actual length-electronic length) in both the apex locators in the presence of various irrigants before and after preparation

	Irrigant groups	Frequency of difference of more than 0.5 mm	
		Before preparation	After preparation
Root ZX Mini	Group A (0.1% OCT)	12	18
	Group B (2% CHX)	18	26
	Group C (5% NaOCl)	42	50
	Group D (heated 5% NaOCl)	46	58
Propex II	Group A (0.1% OCT)	14	22
	Group B (2% CHX)	26	34
	Group C (5% NaOCl)	56	62
	Group D (heated 5% NaOCl)	58	66

OCT=Oxetidine dihydrochloride, CHX=Chlorhexidine gluconate, NaOCl=Sodium hypochlorite

DISCUSSION

OCT is a bispyridine derivative with two noninteracting cationic active centers in its molecule, separated by a long aliphatic hydrocarbon chain which binds readily to negatively charged surfaces. It has high antimicrobial efficacy due to its strong adherence to cardiolipins, bacterial cell membrane components with minimal adverse effects on the human epithelial cells. On attachment, it causes cell death and leakage of the cytoplasmic membrane by its interaction with polysaccharides in the cell wall of microorganisms and cytoplasmic bacterial enzymatic systems. OCT has a broad antimicrobial spectrum, including Gram-positive and Gram-negative bacteria, chlamydiae, mycoplasma, and fungi. OCT has been reported to be superior to CHX and alexidine, and its antimicrobial efficacy is three to ten

Table 2: Mean difference between the actual length and the electronic length by Root ZX Mini and Propex II in the presence of various irrigants in the root canal (mm) before and after preparation

Group	Preparation stage	Apex locator	Mean	SD	<i>t</i> -test	<i>P</i>
Group A (0.1% OCT)	Before preparation	Root ZX Mini	+0.2000	0.50383	0.576	0.567
		Propex II	+0.1375	0.46668		
	After preparation	Root ZX Mini	+0.1875	0.55108	0.400	0.690
		Propex II	+0.1375	0.56600		
Group B (2% CHX)	Before preparation	Root ZX Mini	+0.1625	0.45836	1.351	0.181
		Propex II	+0.0250	0.45220		
	After preparation	Root ZX Mini	+0.0375	0.47214	0.338	0.736
		Propex II	0.0000	0.51887		
Group C (5% NaOCl)	Before preparation	Root ZX Mini	-0.2125	0.55340	0.187	0.852
		Propex II	-0.1875	0.63738		
	After preparation	Root ZX Mini	-0.4750	0.47972	0.113	0.911
		Propex II	-0.4625	0.51125		
Group D (heated 5% NaOCl)	Before preparation	Root ZX Mini	-0.0750	0.64599	0.597	0.552
		Propex II	-0.1625	0.66398		
	After preparation	Root ZX mini	-0.4750	0.50574	0.319	0.751

OCT=Oxetidine dihydrochloride, CHX=Chlorhexidine gluconate, NaOCl=Sodium hypochlorite, SD=Standard deviation

times higher than that of CHX. It shows balanced activity against Gram-positive and Gram-negative bacteria, unlike CHX which is more effective against Gram-positive bacteria. Studies have shown fast antimicrobial efficacy after 1 min application against *Staphylococcus aureus*, *Streptococcus pyogenes*, *Escherichia coli*, and *Candida albicans*, even in the presence of blood or wound exudates. It can be an alternative endodontic irrigant to CHX based on its high antimicrobial effect and lower cytotoxicity. However, there is limited information regarding the efficacy of apex locators in the presence of OCT. Hence, in the present study, OCT was compared to the other contemporary irrigants such as NaOCl and CHX.^[6,7]

Various ways to simulate *in vivo* conditions to determine working length include 1% agar, gelatin, alginate, and flower sponge soaked in 0.9% saline and alginate models. The model of choice in the present study was alginate because it is acceptable and has demonstrated to have good electroconductive properties. Furthermore, the periodontal ligament was simulated more efficiently due to its colloidal consistency. It is not only easy to prepare but also good in handling and has a stable set-up to test EALs for up to 45 days. One probable disadvantage of this model is that it is not able to completely simulate the *in vivo* conditions. In addition, premature readings can be attained if the alginate leaks through the apical foramen although it is more common with more fluid media. To prevent any bias due to the dimensional change of the alginate, irrigation solutions and EALs were varied systematically.^[8,9]

The first part of null hypothesis for the accuracy of apex locators was upheld because there were no statistically significant differences between the two EALs in locating the AF. Similar results of accuracy of 90.21%, 89.02%, and 82.60% were obtained by Çiçek and Bodrumlu for Root ZX Mini, Propex II, and Raypex 5, respectively.^[10] Likewise, in another study, accuracy was found to be 90%, 86.66%, and 80% with iROOT, iPex II, and Propex Pixi.^[11] Among the irrigants used in the apex locators, 0.1% OCT showed the highest accuracy and 5% heated hypochlorite showed the least accuracy. The possible explanations for the results could be the high electroconductivity (66 mS) of NaOCl.^[3] It has been demonstrated in previous studies that if high electroconductive solutions are present inside the canal, it greatly reduces the impedance of apex locators resulting in decrease in working length measurements.^[2] Contradictory outcome has been reported by Janeczek *et al.* wherein both 2% and 5.25% NaOCl gave the most favorable results with the use of both stainless steel and nickel-titanium files.^[12] Intragroup comparison

among irrigants in decreasing order was as follows: OCT >CHX >NaOCl >heated NaOCl. Similar result has been reported in a recent study by Altunbaş *et al.*, where least accurate results were found in the presence of NaOCl in teeth with perforation when using Dentaport ZX.^[13] The least accuracy in the presence of heated NaOCl could be due to an increase in chlorine content with increase in temperature. Furthermore, the decomposition rate of unstable hypochlorite anions into chlorate and chlorine ions is increased with increase in temperature, which in turn may affect the accuracy.^[5]

In the present study, OCT and CHX affected the apex locators least which is in accordance with other research papers too.^[14-16] Khattak *et al.* have also reported CHX to have lesser effect than sodium hypochlorite on Root ZX Mini.^[17] CHX showed closer measurements to the ALs in the present study. This is also in accordance with an *in vivo* study conducted by Ozsezer *et al.*, in which closer measurements to the actual length were obtained in the presence of CHX solution.^[18] Jain and Kapur also found that the mean difference in Root ZX Mini and Propex II before and after enlargement in the presence of 2% CHX was statistically insignificant.^[14] A study done by Duran-Sindreu *et al.* also found insignificant difference in the efficacy of Root ZX Mini in the presence of 2% CHX.^[15]

The effect of canal preparation (to #30 K file) was also evaluated for the two EALs in the presence of irrigants. Few cases showed a decrease in the estimated working length after preparation, but there was no statistically significant difference between the apex locators or between the irrigants. The reason behind the decrease in working length found in some of the samples may be because of blockage of canal by dentinal shavings after preparation even though this difference is statistically insignificant. This is in agreement with a study conducted by Jain and Kapur in which they found difference in readings before and after preparation of the canal, with no statistically significant results.^[14]

Propex II showed higher rate of overestimation than Root ZX Mini. Earlier *in vivo* studies have reported higher overestimation with Propex II in comparison to Raypex and apex NRG.^[16] Another *in vivo/ex vivo* study demonstrated that Propex II showed largest error in the presence of NaOCl (50%), suggesting that the higher electroconductive irrigating solutions affected the precision of multifrequency apex locators.^[2] Both the apex locators showed overestimation in the presence of OCT and CHX and underestimation in the presence of NaOCl heated and nonheated as seen in Table 2. In accordance with the present study, previous reports have suggested that high electroconductive solutions showed

underestimation whereas low electroconductive medium showed overestimation.^[16] The present study indicates that accuracy of apex locators in the presence of certain irrigants as heated hypochlorite may be diminished. The clinician should be aware of these possibilities so that EALs can be used with most accurate outcome.

CONCLUSION

Under the *in vitro* condition of the study, the following conclusions can be drawn:

1. Root ZX Mini was more consistent than Propex II in more number of samples and performed accurately in the presence of various irrigants
2. The accuracy in the presence of 0.1% OCT and 2% CHX was higher than 5% NaOCl heated and nonheated in both the EAL
3. In both, the EAL overestimation was seen in the presence of 0.1% OCT and 2% CHX and underestimation was seen in the presence of 5% sodium hypochlorite heated and nonheated
4. Cleaning and shaping had no effect on the accuracy of EAL even though a slight decrease in the accuracy was seen after preparation in some of the samples.

The conclusions drawn in the present study should be considered with caution as the study was performed under *in vitro* conditions. Furthermore, *in vivo* studies with the similar irrigants are needed to better evaluate the accuracy of Root ZX Mini and Propex II and to substantiate the present results.

FINANCIAL SUPPORT AND SPONSORSHIP

Nil.

CONFLICTS OF INTEREST

There are no conflicts of interest.

REFERENCES

1. Tampelini FG, Coelho MS, Rios MA, Fontana CE, Rocha DGP, Pinheiro SL, *et al.* *In vivo* assessment of accuracy of Propex II, Root ZX II, and radiographic measurements for location of the major foramen. *Restor Dent Endod* 2017;42:200-5.
2. Khursheed I, Bansal R, Bansal T, Singh HP, Yadav M, Reddy KJ, *et al.* A comparative evaluation of working length with digital radiography and third generation apex locator (ProPex) in the presence of various intracanal irrigants: An *in vivo/ex vivo* study. *Dent Res J (Isfahan)* 2014;11:56-60.
3. Mull JP, Manjunath V, Manjunath M. Comparison of accuracy of two electronic apex locators in the presence of various irrigants: An *in vitro* study. *J Conserv Dent* 2012;15:178-82.
4. Reynoso RF, Nazario RN, Rodriguez J, Bittencourt BF, Dominguez JA. Influence of irrigant solutions and apex locators in working length determination. *J Oral Health Dent Sci* 2017;1:103.
5. Sirtes G, Waltimo T, Schaeztle M, Zehnder M. The effects of temperature on sodium hypochlorite short-term stability, pulp dissolution capacity, and antimicrobial efficacy. *J Endod* 2005;31:669-71.
6. Cherian B, Gehlot PM, Manjunath MK. Comparison of the antimicrobial efficacy of octenidine dihydrochloride and chlorhexidine with and without passive ultrasonic irrigation – An *in vitro* study. *J Clin Diagn Res* 2016;10:ZC71-7.
7. Assadian O. Octenidine dihydrochloride: Chemical characteristics and antimicrobial properties. *J Wound Care* 2016;25:S3-6.
8. Carvalho AL, Moura-Netto C, Moura AA, Marques MM, Davidowicz H. Accuracy of three electronic apex locators in the presence of different irrigating solutions. *Braz Oral Res* 2010;24:394-8.
9. Al-Hadlaq SM. Evaluation of two compact electronic apex locators in the presence of different endodontic solutions. *Saudi J Dent Res* 2012;3:7-12.
10. Çiçek E, Bodrumlu E. Influence of newly developed and conventional irrigants on the accuracy of three electronic apex locators. *Oral Health Dent Manag* 2015;14:179-82.
11. Saxena D, Saha SG, Bharadwaj A, Vijaywargiya N, Dubey S, Kala S, *et al.* A comparative evaluation of accuracy of three electronic apex locators using histological section as gold standard: An *ex vivo* study. *J Conserv Dent* 2017;20:251-4.
12. Janeczek M, Kosior P, Piesiak-Pańczyszyn D, Dudek K, Chrószcz A, Czajczyńska-Waszkiewicz A, *et al.* The effect of file size and type and irrigation solutions on the accuracy of electronic apex locators: An *in vitro* study on canine teeth. *Biomed Res Int* 2016;2016:8594087.
13. Altunbaş D, Kuştarıcı A, Toyoğlu M. The influence of various irrigants on the accuracy of 2 electronic apex locators in locating simulated root perforations. *J Endod* 2017;43:439-42.
14. Jain S, Kapur R. Comparative evaluation of accuracy of two electronic apex locators in the presence of various irrigants: An *in vitro* study. *Contemp Clin Dent* 2012;3:S140-5.
15. Duran-Sindreu F, Gomes S, Stöber E, Mercadé M, Jané L, Roig M, *et al.* *In vivo* evaluation of the iPex and root ZX electronic apex locators using various irrigants. *Int Endod J* 2013;46:769-74.
16. Milanovic I, Ivanovic V, Vujaskovic M, Ignjatovic S, Miletic V. Accuracy of three electronic apex locators in determining the apical foramen in multi-rooted teeth: Randomised clinical and laboratory study. *Aust Endod J* 2015;41:35-43.
17. Khattak O, Raidullah E, Francis ML. A comparative assessment of the accuracy of electronic apex locator (Root ZX) in the presence of commonly used irrigating solutions. *J Clin Exp Dent* 2014;6:e41-6.
18. Ozsezer E, Inan U, Aydin U. *In vivo* evaluation of ProPex electronic apex locator. *J Endod* 2007;33:974-7.