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Research Article

Accuracy of Different Apex Locators in presence of Newer Irrigants- An *invitro* study

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Abstract

Introduction: The study compared accuracy of J Morita- Root ZX mini (multiple frequency based), Woodpecker gold V (multiple frequency based), Coltene Canal pro (multiple frequency based) apex locators with the irrigating solutions, NaOCl, Endosolv, Citric acid, HEBP.

Methodology: The actual root canal length of teeth were measured using a 10 size K file under a dental operating microscope. The samples were mounted in alginate model and the electronic working length was recorded in both dry and wet (with irrigants). Variation in the readings of EALs after blockage was compared with actual length (measurement under microscope). The error was subjected to statistical analysis (ANOVA test and Post hoc Bonferroni test).

Results: The mean overall (dry and wet canal) error for Root zx mini was 0.116 mm with maximum and minimum error range of: -2.1 to 1.5mm. The overall (dry and wet canal) mean error for Woodpex 5 was 0.305 within a range of: -1 mm to 1.80mm.The overall (dry and wet canal) mean error for Coltene canal pro was 0.271 within a range of : -2.100 to 1.80.

Conclusion: Root ZX mini was the most accurate EAL amongst all the three EALs used in this study in both wet and dry conditions. Amongst the 4 irrigants used, all the three EALs recorded the highest deviation from actual length in presence of Citric acid.

Keywords: Apex Locators; Irrigants; Working Length

Introduction

The cementum-dentine junction (CDJ) is assumed to be the ideal limit for endodontic instrumentation. Kuttler showed establishing the exact limit of the CDJ is not simple [1].

Custer (1918) coined the use of electronic devices to measure working length. Sunada (1962) was the first to design such a simple device. Irrigants are used for the biomechanical preparation and have the ability to affect the accuracy of such devices [2].

Any fluid can reduce electrical impedance of the root canal walls and establish better electrical contact with periapical tissues due to its property of high electrical conductivity. Khattak., *et al.* and Khursheed., *et al.* got best accuracy in 0.2% chlorhexidine but in 3.0% NaOCl, some error was observed [3].

To our knowledge no earlier study has been done to compare the accuracy of JMorita Root ZX mini, Woodpecker gold V, Coltene Canal pro (Figure 1a) with the irrigating solutions sodium hypochlorite, Endosolv, Citric acid, HEBP.

Material and Methods

40 single rooted human permanent teeth were selected. Each tooth was examined radiographically for presence of single root canal and sectioned at CEJ using diamond discs. The actual root canal length was measured with 10 size K file into the root canal until file was just visible at the apical foramen under a dental operating microscope (Seimorr Corp) under 10x magnification (Figure 1d). Subtraction of 0.5 mm was done from the actual length to determine exact working length.

40 teeth were randomized into four Groups according to the experimental intracanal irrigant

- Group I: 3% NaOCl (Zoodenta)
- Group II: 40% citric acid (Cerkamed India)
- Group III: Endosolv (Septodont)
- Group IV: 9% HEBP (Maarc dental products) (Figure 1c).

Teeth were mounted in the alginate model and was used within 2 hours of mixing of alginate. Alginate is a good medium to establish the necessary electric circuit for a correct electronic EAL measurement, because it mimics well the electric impedance of the human periodontium [4,5].

The lip clip was inserted in contact with alginate. The electronic working length of each tooth was measured in alginate circuit with all the EALs without any irrigants in the canals. Readings were recorded when it was stable for 5 seconds (Figure 1b).

0.5 ml Irrigant was introduced in the canal of group. Electronic working length measurement was noted with Root ZX.

Similarly, the (wet) electronic working length was measured with other two apex locators for all specific groups.

Figure 1: 1a.Apex locators- Woodpex5, Canal Pro, RootZX Mini, 1b. Technique of measuring WL, 1c. Four irrigants, 1d. Estimation of actual working length under microscope

The readings were subjected to statistical analysis(ANOVA and Post hoc Bonferroni test).

Results

The accuracy of the apex locators was determined based on the error as a parameter.

	N	Mean	SD	SEM	95% C.I.		Min.	Max.
					Lower	Upper		
ROOT ZX MINI	80	0.116	0.540	0.060	-0.004	0.236	-2.100	1.500
WOODPEX 5	80	0.305	0.488	0.055	0.197	0.413	-1.000	1.800
CANAL PRO	80	0.271	0.437	0.049	0.174	0.368	-1.000	1.500
Total	240	0.231	0.495	0.032	0.168	0.294	-2.100	1.800

Table 1: Pooled data (NaOCl + Citric acid + Endosolv + HEBP + Dry) Descriptives for Pooled data.

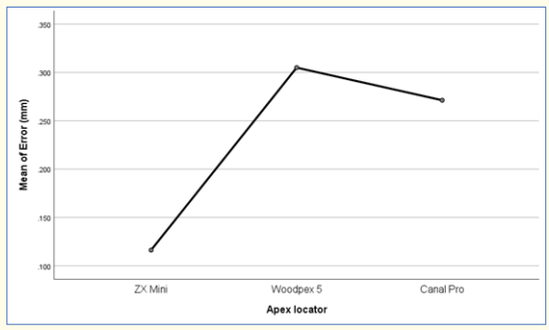
The mean overall (dry and wet canal) error for Root zx mini was 0.116 mm with maximum and minimum error range of : -2.1 to 1.5mm.

The overall (dry and wet canal) mean error for woodpex 5 was 0.305 within a range of: -1 mm to 1.80mm.

The overall (dry and wet canal) mean error for coltene canal pro was 0.271 within a range of: -2.100 to 1.800.

ANOVA (ZX Mini + Woodpex 5 + Canal Pro)

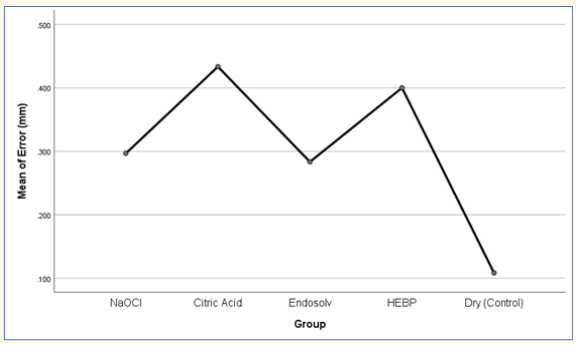
There was statistical significance with p value of 0.002 with ANOVA test.



Graph 1: Means plot for apex locators.

	N	Mean	SD	SEM	95% C.I. for Mean		Min.	Max.
					Lower	Upper		
NaOCl	30	0.297	0.632	0.115	0.061	0.533	-2.100	1.200
Citric Acid	30	0.433	0.471	0.086	0.258	0.609	-0.800	1.300
Endosolv	30	0.283	0.586	0.107	0.065	0.502	-0.700	1.800
HEBP	30	0.400	0.366	0.067	0.263	0.537	-0.200	1.100
Dry (Control)	120	0.108	0.435	0.040	0.030	0.187	-1.000	1.400
Total	240	0.231	0.495	0.032	0.168	0.294	-2.100	1.800

Table 2: Pooled data (ZX Mini + Woodpex 5 + Canal Pro) Descriptives for Pooled data.



Graph 2: Means plot for irrigants.

The mean error by all the apex locators was the highest in citric acid i.e., the group 2 with a mean error of 0.433mm followed by HEBP-0.4 mm, NaOCl - 0.397 and Endosolv - 0.283mm.

The least mean error by all the 3 apex locators was observed in dry condition (i.e.,) 0.108mm.

The Post-hoc (Bonferroni) test for the pooled of dry group and NaOCl group reveals a significance of 0.56. While the significance was 0.011, 0.76, 0.033 when compared with Citric acid, Endosolv and HEBP.

		Mean Difference (I-J)	Std. Error	Sig.	95% C.I.	
(I)	(J)				*Lower*	*Upper*
NaOCl	Citric Acid	-0.137	0.124	1.000	-0.489	0.215
	Endosolv	0.013	0.124	1.000	-0.339	0.365
	HEBP	-0.103	0.124	1.000	-0.455	0.249
	Dry (Control)	0.188	0.098	0.563	-0.090	0.467
Citric Acid	NaOCl	0.137	0.124	1.000	-0.215	0.489
	Endosolv	0.150	0.124	1.000	-0.202	0.502
	HEBP	0.033	0.124	1.000	-0.319	0.385
	Dry (Control)	0.325	0.098	0.011	0.047	0.603
Endosolv	NaOCl	-0.013	0.124	1.000	-0.365	0.339
	Citric Acid	-0.150	0.124	1.000	-0.502	0.202
	HEBP	-0.117	0.124	1.000	-0.469	0.235
	Dry (Control)	0.175	0.098	0.760	-0.103	0.453
HEBP	NaOCl	0.103	0.124	1.000	-0.249	0.455
	Citric Acid	-0.033	0.124	1.000	-0.385	0.319
	Endosolv	0.117	0.124	1.000	-0.235	0.469
	Dry (Control)	.291667*	0.098	0.033	0.013	0.570
Dry (Control)	NaOCl	-0.188	0.098	0.563	-0.467	0.090
	Citric Acid	-0.325	0.098	0.011	-0.603	-0.047
	Endosolv	-0.175	0.098	0.760	-0.453	0.103
	HEBP	-0.292	0.098	0.033	-0.570	-0.013

Table 3: Post-hoc (Bonferroni) test for Pooled data.

Discussion

Our study was based on four irrigants based on which the samples were grouped as follows

- **Group I-NaOCl:** NaOCl has antimicrobial property which increases with its concentration, low viscosity, good shelf life [6]. This solution was selected because it is a strong electrolyte (Conductivity of 88 miliSiemens) and can influence the readings of an apex locator [7].
  - Additionally, NaOCl can ingress in dentinal tubules and lead to reduction in the impedance, thus causing an increase in electronic working length [3].
- **Group II-Citric acid:** Citric acid in concentration of 10% can effectively remove smear layer. According to some invitro studies the biocompatibility of 10% citric acid was found to be better than 17% EDTA-T and 17% EDTA. The Electrical Conductivity κ in mS/cm for 25% citric acid was 7.1, thus it can be noted that citric acid is a far weaker electrolyte than hypochlorite. Janeczek., *et al.* observed a significant error in electronic working length when 40% citric acid was used as irrigant [3].
- **Group III- Endosolv:** EAL have shown to show a shorter electronic working length when used in Reso Solv and Endosolv E. The newly developed ENDOSOLV by Septodont has both resin sealer and eugenol sealer dissolving properties. There has been no study to check the accuracy of apex locators in ENDOSOLV. This makes our study unique and our study is the first one in literature to check its efficacy with different apex locators.
- **Group IV-Hydroxyethylidene bisphosphonate**: (HEBP) (1-hydroxyethylidene- 1, 1-bisphosphonate), also known as etidronic acid or etidronate, is a decalcifying agent that shows mild interaction with NaOCl. It can be used as a substitute to citric acid or EDTA.HEBP is used in patients suffering from Paget's disease and osteoporosis systemically and can also avert bone resorption [8].

As for the other EALs, significant differences in accuracies in the presence of various irrigants were reported by Fouad., *et al.* This present study also shows similar results. Root ZX is the most studied EAL. The contemporary EALs are being tested against the Root ZX since it is considered as the gold standard. The manufacturers claim that Root ZX mini is a compact version of the originally developed Root ZX, can be relied in the wet canals also. It follows the same principle of working as the originally developed Root ZX [9].

In our study the error was recorded by subtracting the electronic length from the actual (AL-EL). A negative error means a longer recorded electronic working length. While a positive error value means a shorter electronic working length.

In our study the mean overall (dry and wet canal) error for Root ZX mini was 0.116 mm within a range -2.1 and 1.5mm. Root ZX mini was found to be the most accurate amongst the three EALs in dry condition as well as in all the four irrigants. (Refer Graph no. 1 and table no.1).

The overall (dry and wet canal) mean error for Coltene Canal Pro was 0.271 within a range of - 2.100 to 1.800. (Refer Graph no.1 and table no.1). This came out to be the second most accurate EAL in our study.The overall (dry and wet canal) mean error for Woodpex 5 was 0.305 within a range of: - 1 mm to 1.80mm. Woodpex 5 came out to be the least accurate of all the three EALs. (Refer Graph no. 1 and table no.1).

Evaluation of Root ZX in 2% lidocaine with 1: 100,000 epinephrine, 5.25% NaOCl, RC Prep, liquid EDTA, 3% hydrogen peroxide and Peridex was done by Jenkins., *et al*. Root ZX could estimate the working length in all the irrigating solutions within 0.31 mm, The largest errors were observed in NaOCl [10].The accuracy can be attributed to the physics and principle behind the working of Root ZX series (Third generation). The EAL uses the ratio of impedances at two frequencies to derive a electronic working length. Another principle is measuring impedance characteristics using more than two frequencies which is used in the Endo Analyzer 8005 (Analytic Endodontics), Woodpecker Woodpex 5 and AFA Apex Finder 7005 (Analytic Endodontics) five different frequencies have been used and the device measures both components (phase and amplitude) of impedance at each frequency. These figures are then analysed in a procedure to determine the location of the minor diameter. It detects the canal terminus by determining a sudden change in the dominant characteristic (capacitive or resistive) of the impedance [11]. In an *ex vivo* study Root ZX was more accurate at 96.6% accuracy and Raypex 5 (4th generation) was 93.2%. The results of the study were not statistically significant [12].

Although there was been no direct comparative study between Root ZX mini and Woodpex 5. There were other studies which compared the 3rd gen Root ZX with other multifrequency based 4th generation EALs.

In an *ex vivo* study Root ZX was more accurate at 96.6% accuracy and Raypex 5 (4th generation) was 93.2%. The results of the study were not statistically significant [12]. Mull., *et al.* compared Root ZX with Sybron endo mini EAL and found that Root ZX was a more accurate and reliable machine. However, the Sybron endo (4th generation) was more accurate in NaOCl and CHX. The 1% NaOCl (66 mS- electroconductivity, pH 11.72) and 17% EDTA (40 mS, pH 7.01) showed short EALs. The 2% CHX (1 mS, pH 6.5) irrigant exhibited longer EWLs with Root ZX (P = 0.001) and Sybron Mini (P = 0.542) [9]. The precision of (Root ZX) was within 0.19 mm from minor diameter while that for Endo Analyzer (multiple frequency based EAL) was 1.03 mm; The minor diameter was located 90.7% of the times for the Root ZX and 34.4% for the Endo Analyzer Model 8005. The results of this study were analogous to our study where the ratio-based EAL Root ZX mini was found to be more accurate than the multifrequency based EALs [11].

Altunbas., *et al*. studied that DentaPort ZX 3rd generation found major diameter with 100% precision within ± 0.5 mm. For SIRO-Endo (Pocket 4th gen) and Rootor(4th gen) accuracy in locating the major foramen within ± 0.5 mm was 73.3% and 86.7%, respectively [13].

In the present study third generation of EAL (Root ZX mini) was more accurate than the fourth generations (Coltene Canalpro and Woodpex 5). (Graph. no. 1 and table no.1). Also in our study the overall mean error by all the EALs was the highest in citric acid i.e. the group II with a mean error of 0.433mm followed by HEBP – 0.4 mm, NaOCl – 0.397 and Endosolv - 0.283mm.The least mean error by all the 3 EALs was observed in dry condition i.e. 0.108mm. (Refer Graph no. 2 and table no.2).

The results showed a statistical significance (p = 0.002) with ANOVA test when the highest error amongst the irrigants and in dry condition was analysed.

The results of our study are in consensus with Maciej Janeczek., *et al*. He observed statistically significant (p < 0.001) error in the electronic working length when 40% Citric acid (Group II) was used for irrigation. However, the EALs used by him were Endopilot (Schlumbohm, Brokstedt, Germany and iPex (NSK, Tochigi, Japan) which are both 4th generation EALs [3]. Root ZX mini proved to be the most accurate EAL in citric acid with a mean error value of 0.22 mm. This result is similar to study carried out by Shahnaz. Shahnaz found a mean error of 0.292 when Root ZX mini was used in electronic working length determination [14]. No study has been carried out until now to check the accuracy of Coltene canal pro and Woodpex in citric acid. This makes our study distinctive.

Woodpex 5 showed the highest error of 0.610 mm; followed by Canal pro with a mean error of 0.470 mm in our study. Woodpex 5 and Coltene Canalpro have lesser accuracy due to the electroconductive property of the irrigants. The literature review revealed that there are no studies evaluating the accuracy of Woodpex 5 in diverse irrigants.

Second highest error was observed in HEBP – group IV. The least error in group IV irrigant was observed with Root ZX mini EAL with a mean error of 0.360 mm. Canal pro and Woodpex 5 had the showed similar mean error of 0.42 mm. The literature review does not show any history of HEBP being used in any study to check the accuracy of EALs in it. Thus, our study becomes the first one to review HEBP for use with EALs.

HEBP being a milder chelating agent than EDTA has shown lesser detrimental effects on root dentine. 18% HEBP + NaOCl when used as a final irrigation protocol; has shown the highest push out bond strength with calcium silicate cements. Thus, the advantage of HEBP cannot be ignored where the use of calcium silicate-based cement is inevitable [15]. Canals irrigated with HEBP had improved bond strength of resin sealers than those which were irrigated with EDTA and MTAD. The reduction of Ca++ can change the strength of adhesion [16].

The third highest error was observed in group I - NaOCl (i.e.,) a mean error of 0.397 mm (Refer Graph. no. 2). In Graph no. 3, the least error in group I irrigant was observed with Root ZX mini EAL with a mean error of 0.120 mm. Woodpex 5 showed the highest error of 0.450 mm in our study; followed by Canal pro with a mean error of 0.320 mm.

As observed from the data there was a tendency to show a longer electronic working length by all the three EALs in the presence of NaOCl.

When there is a conducting liquid in the canal, there is no sudden change in the conductive properties of root canal wall as the file approaches the apex; which is a requirement by the EALs. Meredith and Gulabiwala reported that there was a clear increase in series resistance with increasing distance from the radiographic apex for dry canals (22.19-92.07 kΩ) and these figures were markedly higher than for those containing deionized water (9.32-12.10 kΩ) and NaOCl (7.46-8.92 kΩ). It is easier to measure the electrical changes in dry canals and therefore it the performance by some EALs is better. Kim., *et al.* showed that the EWLs were longer in high electroconductive NaOCl, and lower in less electroconductive hydrogen peroxide [17].

Goel., *et al.* (2006) and Jain., *et al*. (2012) observed significant error in readings of Root ZX in presence of 2.5% of NaOCl. However, the observations by Meares WA., *et al*. were contradictory when same EAL in same solution were used [18,19]. Jenkins., *et al*. (2001) found Root ZX to be reliable in all irrigants but with large deviation in NaOCl [10].

Our study was consistent with the results of Meares., *et al*. where he found a mean error of Root ZX as 0.11mm in 2.125% NaOCl [20]. (Refer Graph no. 1 and table no. 1).

The least error was caused in Endosolv - group III by all the three EALs.The least error in group III irrigant was observed with Root ZX mini EAL with a mean error of 0.08 mm. Canal pro showed the highest mean error of 0.430 mm; followed by Woodpex 5 with a mean error of 0.340 mm. As observed from the data there was a tendency to show a shorter electronic working length by Root ZX mini in the presence of Endosolv. Endosolv is basically made of Ethyl acetate 50-100% and 2 (or 3) -methylbutyl acetate. It is the acetate ester formed between acetic_acid and ethanol. It is an acetate ester, an ethyl ester and a volatile organic compound [21]. The organic nature makes it a poor conductor of electricity. The tendency of Root ZX mini to show a shorter working length in Endosolv can be attributed to the poor electrical properties of the organic solution [22]. For Root ZX, the presence of electrolytes inside the canal reduces its resistance and increases its capacitance. This favors its circuit as it depends on differentiating the modulation in electrical capacitance near the AF [23].

Conclusion

Root ZX is most accurate out of the three apex locators, in dry condition as well as in presence of four different irrigants. Among the irrigants, Citric acid caused the highest error in the working length of all the three apex locators with overall mean error of 0.43 mm.

Within the limitations of this study, the ideal combination depending on the indications for usage, would be Root ZX along with Etidronic acid (HEBP) for accurate working length determination.

Bibliography

1. Kuttler Y. "Microscopic investigation of root apexes". *Journal of the American Dental Association* 50 (1955): 544-552.

2. Shahnaz. "Effect of different irrigating solutions on electronic working length determination of root canals: An *in vitro* study". *International Journal of Applied Dental Sciences* 5 (2019): 113-115.

3. Maciej Janeczek., *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 Research International* (2016).

4. Okba Mahmoud., *et al.* "Comparative Evaluation of Accuracy of Different Apex Locators: Propex IQ, Raypex 6, Root ZX, and Apex ID with CBCT and Periapical Radiograph 8212 *In Vitro* Study". *International Journal of Dentistry* (2021).

5. Nikhil Puri., *et al.* "An *in vitro* comparison of root canal length determination by DentaPort ZX and iPex apex locators". *Journal of Conservative Dentistry* 16 (2013): 555-558.

6. Soumya Abraham., *et al.* "*Journal of Pharmaceutical Sciences and Research* 7 (2015): 5-9.

7. Guerisoli DMZ., *et al.* "Evaluation of some physico-chemical properties of different concentrations of sodium hypochlorite solutions". *Brazilian Endodontic Journal* 3 (1998): 21-23.

8. Agrawal Vineet S., *et al.* "A Contemporary Overview of Endodontic Irrigants - A Review". *Journal of Dental Applications* 1.6 (2014): 105-115.

9. Tinaz AC., *et al.* "A simple model to demonstrate the electronic apex locator". *International Endodontic Journal* 35 (2002): 940-945.

10. Joslyn A Jenkins., *et al.* "An *In Vitro* Evaluation of the Accuracy of the Root ZX in the Presence of Various Irrigants". *Journal of Endodontics* 27 (2001): 209-211.

11. Aaron R Welk., *et al.* "An *In Vivo* Comparison of Two Frequency-based Electronic Apex Locators". *Journal of Endodontics* 29 (2003): 497-500.

12. Swapna DV., *et al.* "Comparison of third generation versus fourth generation electronic apex locators in detecting apical constriction: An *in vivo* study". *Journal of Conservative Dentistry* 18 (2015): 288-291.

13. Altunbaş D., *et al.* "Comparison of various current electronic apex locators to determine the working length using the clearing technique". *Nigerian Journal of Clinical Practice* 18 (2014): 359-363.

14. Shahnaz. "Effect of different irrigating solutions on electronic working length determination of root canals: An *in vitro* study". *International Journal of Applied Dental Sciences* 5 (2019): 113-115.

15. Prasanna Neelakantan., *et al.* "The effect of root dentin conditioning protocols on the push-out bond strength of three calcium silicate sealers". *International Journal of Adhesion and Adhesives* 60 (2015): 104-108.

16. Gustavo De-Deus., *et al.* "Soft Chelating Irrigation Protocol Optimizes Bonding Quality of Resilon/Epiphany Root Fillings". *Journal of Endodontics* 34 (2008): 703-705.

17. N Meredith and K Gulabivala. "Electrical impedance measurements of root canal length". *Endodontics and Dental Traumatology* 13 (1997): 126-131.

18. S Kapur R. "Comparative evaluation of accuracy of two electronic apex locators in the presence of various irrigants: An *in vitro* study". *Contemporary Clinical Dentistry* 3 (2012): 140-145.

19. Goel Y., *et al.* "A comparative evaluation of the accuracy of third generation electonic apex locator (Root ZX) in presence of various intracanal irrigants". *Journal of Endodontology* 18 (2006): 28-33.

20. W Anthony Meares., *et al.* "The Influence of Sodium Hypochlorite Irrigation on the Accuracy of the Root ZX Electronic Apex Locator". *Journal of Endodontology* 28 (2002): 595-598.

21. CHEBI:27750 - ethyl acetate.

22. Yakup Ustun., *et al.* "Hindawi Publishing Corporation. Effects of Dissolving Solutions on the Accuracy of an Electronic Apex Locator-Integrated Endodontic Handpiece". *The Scientific World Journal* (2013).

23. Taneja S., *et al.* "Comparative Evaluation of Accuracy of Three Electronic Apex Locators in Different Simulated Clinical Conditions- An invitro Study". *Annals of Medical and Health Science Research* 7 (2017): 190-194.