How to Cite:
Desai Urooj, I., Chintan, J., Sweety, T., Hajoori Mustafa, Z., Patel Dritali, V., & Tejal, K. (2022). Working length determination: Comparative analysis of integrated & electronic apex locator in various irrigating solutions. *International Journal of Health Sciences*, *6*(S4), 11720–11729. https://doi.org/10.53730/ijhs.v6nS4.11282

Working length determination: Comparative analysis of integrated & electronic apex locator in various irrigating solutions

Desai Urooj I.
Post Graduate Student, Department of Conservative Dentistry and Endodontics, Karnavati School of Dentistry. Karnavati University, Gandhinagar-382422, Gujarat, India

Joshi Chintan
Professor and Head of Department, Department of Conservative Dentistry and Endodontics, Karnavati School of Dentistry. Karnavati University, Gandhinagar-382422, Gujarat, India
Corresponding author email: chintanjoshi@karnavatiuniversity.edu.in

Thumar Sweety
Reader, Department of Conservative Dentistry and Endodontics, Karnavati School of Dentistry.Karnavati University, Gandhinagar-382422, Gujarat, India

Hajoori Mustafa Z.
Post Graduate Student, Department of Conservative Dentistry and Endodontics, Karnavati School of Dentistry, Karnavati University, Gandhinagar-382422, Gujarat, India

Patel Dritali V.
Post Graduate Student, Department of Conservative Dentistry and Endodontics, Karnavati School of Dentistry, Karnavati University, Gandhinagar-382422, Gujarat, India

Kachalia Tejal
Department of Conservative Dentistry and Endodontics, Karnavati School of Dentistry, Karnavati University, Gandhinagar-382422, Gujarat, India.

***Abstract*---**Introduction: Working length (WL) determination is one of the crucial steps in endodontic treatment. Conventional Apex locators (EAL) are consistently employed nowadays for WL determination. Apart from the EAL, Integrated apex locators (IAL) have also come into the market that aim to reduce the number of steps. Objectives: The objective of this in vitro study was to compare and evaluate the accuracy of Eighteeth E-Connect S (IAL) and Root ZX Mini (EAL) in

two different irrigating solutions. Methodology: Thirty freshly extracted, single-rooted teeth were taken. The teeth were then individually mounted on an alginate mould. The measurements of the mounted samples of both the groups were taken accordingly based on the irrigating solutions. WL determination was done one by one with both Conventional Apex locator & Integrated apex locator, respectively in 3% sodium hypochlorite (NaOCl) and 2% Chlorhexidine (CHX). Statistical analysis was performed using One Way ANOVA test. Results: The test results showed that there was no statistically significant difference between EAL & IAL in both groups when compared with the actual WL. Conclusion: Both ALs were equally effective in determining WL at ±0.5mm from the apex in the presence of irrigating solutions, i.e., NaOCl and CHX.

***Keywords*---**chlorhexidine, electronic apex locator, irrigating solutions, sodium hypochlorite, working length.

Introduction

The primary goal of root canal therapy is to abate the tissue debris and bacteria within the root canal system to a predefined apical limit.[1] Working length (WL) determination is one of the crucial steps in endodontic treatment. Limiting instrumentation inside the boundaries of the root canal helps with an accurate assessment of the apical stop. [2] The periradicular inflammation and inadequate cleaning of the apical third are the few possibilities leading to improper WL establishment. Precise tools aid in good treatment outcomes; this procedure may be carried out using several techniques, one of which is an electronic apex locator (EAL) measurement. There are debates about the precision of EAL measurements when it comes to the file size, the diameter of the apical third, and the apical foramen of the root canals. [3,4]

Custer was the first to consider an electronic approach for measuring root length. [5] Since then, EALs from various generations have been introduced. The primary benefit is that it provides chair-side determination of working length up to the cementodentinal junction. This method is simple & fast, but the condition of canal determines how effectively accurate it is. [6] These readings were affected by the canal contents, pulpal tissue fragments, bleeding, and pus. [7] Newer EALs, including the Root ZX Mini (J. Morita Corp., Kyoto, Japan) assert that they are more accurate and less sensitive to intracanal contents. [8]

As a result of additional technological advancements, apex locators have been used in conjunction with endomotors to simultaneously determine the WL during root canal instrumentation. [9] The fundamental mechanism of an integrated apex locator is the "quotient approach," which involves simultaneously calculating the impedance by two frequency ratios. The impedance quotient rapidly decreases once the apex is reached, so this gadget doesn't need to be calibrated. [10]

Irrigating solutions such as NaOCl, Ethylenediamine tetraacetic acid (EDTA), Citric Acid and Hydroxyethylidene Bisphosphonate (HEBP) are used as a mainstay of canal disinfection. However, the presence of these solutions in the canal during WL determination may have an impact on the functionality of WL-measuring electronic instruments. [11] This is because the electrical conductivity of different irrigating solutions may affect the accuracy of the apex locators. And also, the accuracy varies in dry canals and canals irrigated with these solutions. The apical foramen diameter and varying file sizes may also have an impact on the accuracy of these AL. [12]

Few studies have compared the Integrated Locator (IAL) with the Conventional Electronic Apex Locator (EAL) on various factors, most notably the most popular one, irrigating solutions. Only a few studies have compared the Integrated Locator (IAL) and the Conventional Electronic Apex Locator (EAL) on a variety of variables, most notably irrigating solutions. As a result, the current in vitro study's goal is to compare the integrated apex locator and the conventional apex locator in two widely used endodontic irrigants, 3 % sodium hypochlorite (NaOCl) and 2% chlorhexidine (CHX).

Material & Methods

For conducting this study, thirty freshly extracted human permanent single-rooted teeth were taken. These teeth were stored in distilled water. [13] Inclusion Criteria were tooth with fully matured apex, single-rooted tooth, single canal, and tooth with enough crown portion to establish a stable reference point. Restored teeth, multiple canals, cracks, resorbed roots, and calcification were excluded. Two operators carried out the study, and they each independently carried out two of the steps of the procedure. In the first step, a single operator performed WL determination on the extracted tooth while the second operator noted down WLs from Apex locators.

The measurements of all the teeth were taken according to the following format:
Group 1 – 3% NaOCl
Group 2 – 2% CHX

Access Cavity Preparation for these teeth was done with Endo Access Bur (Dentsply Maillefer, Ballaigues, Switzerland). After access was opened, the canal was located & the canal patency was established with the No.10k file (M-Access, Dentsply Maillefer, Ballaigues, Switzerland). Coronal Pre-Enlargement was done with rotary ProTaper SX files (Dentsply Maillefer, Ballaigues, Switzerland) and straight-line access was obtained. The canals were then flushed out with an irrigating solution and dried with paper points. After drying the canals, the actual working length determination was made by the first operator.

Figure 1: Tooth samples are mounted individually on the alginate mould

Each tooth was individually mounted in an alginate Tropicalgin – (Zhermack, Badia Polesine, Italy). (Figure 1) EAL WL reading for Group 1(3% Sodium Hypochlorite) was taken and, thereafter, drying off the root canal thoroughly, reading for Group 2(2% Chlorhexidine) was taken by the second operator. Freshly mixed alginate was poured and a new tooth was mounted, and WL determination for all the samples was done in a similar manner.

- Determination of Actual Working Length (AWL):

The actual working length was determined by inserting a size 10k file into the canal and observing its tip under the operating microscope - Labomed Prima DNT (Labo America Inc., Fremont, US) at a magnification of 16x. [14] (Figure 2)

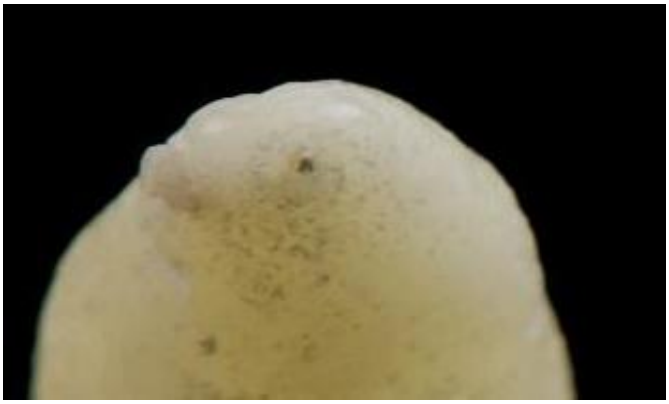

Figure 2: File tip visible through the minor formen when examined under the dental operating microscope

The silicone stopper was then adjusted at the stable occlusal reference point and the working length determination was made. The length was measured and 0.5 mm was subtracted to get the actual working length. This 0.5mm was subtracted as a safety factor to correspond to the apical termination of the root canal at the apical constriction. As the cemento-dentinal junction is 0.5 to 1.01mm from the

anatomical apex.[17] Each measurement was repeated 3 times and the average mean was calculated by the first operator.

After establishing the patency, the lip hook was attached to the alginate mould to complete the circuit in both the Apex Locator devices.

- Determination of Working Length using a Conventional Apex Locator:

The working length determination was done by inserting a 10k file and attaching the clip to the file. Always clip the file holder to the upper part of the file shaft, near the handle. The meter's reading of 0.5 suggests that the file tip is in the apical constriction. The millimetres are not represented by the numbers on the meter gauge. The alarm sound will switch from beeping to a steady tone if the file tip crosses the line that represents the apical point. The terms "APEX" and the little triangle next to the apical line will begin to flash once the file tip enters the major foramen.

- Determination of Working length using Integrated Apex locator:

After completing the circuit, the WL determination was done by attaching a 16/02 glide path file (Proglider- Dentsply Sirona, Patterson Ave, California) to Eighteeth Medical E-Connect S Endomotor (Eighteeth, Jiangsu Province, China) integrated with E-Pex Pro Apex Locator (Eighteeth, Jiangsu Province, China) and inserting the file into the tooth sample till the last green mark was shown on the apex locator. (Figure 3) This device has an Automatic Apical Reverse (AAR) function that stops the file and reverses the rotation once the apex has been reached. The "APEX mark" depicts the tip of the file at the apical foramen, and the "0.5 mm" point on the AAR function is set to stand in for the site of the apical constriction (AC).

Figure 3: Working length determination was carried out using the Integrated Apex locator (IAL).

Analysis was done using IBM SPSS software version 25.0 (SPSS Inc., Chicago, IL, USA). All the working length measurements were obtained and statistical analysis was performed using the One-Way ANOVA test.

Results

One-way analysis of variance, sometimes known as one-way ANOVA, is a statistical method for comparing the means of two or more samples. The One-Way ANOVA test showed that there was no statistically significant difference between the Root ZX and Eighteeth E- Connect S Integrated AL in determining the minor foramen in both groups when compared with actual WL. In table 1, Root ZX mini (EAL) has a higher mean value and Eighteeth E- Connect S (IAL). The mean value of Root ZX mini and Eighteeth E Connect S in group 1 is 20.50±0.437 and 20.40±0.449 and the actual WL is 20.82±0.478 In group 2, the mean value for Root ZX is 20.53±0.445 and Eighteeth E- Connect S is 20.48±0.492 while that of the actual WL is 20.55 ± 0.454.

Table 1: Mean and standard deviation of integrated apex locator and electronic apex locator in group I (NaOCl)

GROUPS		MEAN	N N*	STD. DEVIATION	STD. ERROR	p VALUE*
Group 1	Root ZX Mini	20. 20.50	30 15	4 2.40	0.437	0.084
	Actual WL- Group 1	20.82	303 0 15	2.62	0.478	
Group 1	Eighteeth E-Connect S	20.40	30 15	2.46	0.449	0.085
	Actual WL- Group 1	20.82	303 0 15	2.62	0.478	

*N – No. of samples *p Value- Probability Value

Table 2: Mean and standard deviation of integrated apex locator and electronic apex locator in group 2 (CHX)

GROUPS		MEAN	N N*	STD. DEVIATION	STD. ERROR	p VALUE*
Group 2	Root ZX mini (EAL)	20.53	303 0 15	2.44 2.44	0.445	0.14 0.14
	Actual WL- Group 2	20.5 20.55	303 0 15	2.49 2.49	0.45 0.454	
Group 2	Eighteeth E-Connect Pro (IAL)	20.48	30 15	2.6 2.69	0.492	0. 0.10
	Actual WL- Group 2	20 20.55	30 15	2.49 2.49	0. 0.454	

*N – No. of samples *p Value- Probability Value

Discussion

The study was done in a blinded manner wherein two operators were unaware of readings obtained by each other. Hereby, neither the experimenters nor the

subjects are aware of which subjects are receiving a specific treatment so as to rule out the chances of errors caused by any bias. [15] To simulate the moisture content and avoid desiccation, all of the extracted teeth were preserved in distilled water. As a result, because the solution is neutral, it keeps the teeth moist. [16]

The difficulty with conducting this in vitro study was that it had limitations because this model did not account for the human periodontium. For the time being, many electroconductive materials, including gelatin, agar-agar, alginate, and saline solution, have been employed to imitate the human periodontium and can be used for in vitro evaluation of EALs. [17] In our in-vitro investigation, the tooth is placed in an alginate mould that has been created. This alginate functions as an electrolyte, simulating the periapical tissue of a human. We mounted each tooth separately and recorded the readings one at a time to maintain consistency because chilling inevitably results in moisture loss.

From the literature obtained from various research, the minor apical foramen is considered to be 0.5 to 1.01 mm short of the anatomical apex. [18] Hence, the accuracy criteria of ±0.5mm were considered in our study based on various clinical conditions. In our study, the Root ZX Mini apex locator was used since it is the gold standard in accuracy. It is a third-generation EAL with a 74 % to 97.37 % accuracy rate. [19] While the E Connect S is a multi-frequency-based EAL. [20] These integrated motors with an Integrated EAL have AAR- Automatic Apical Reverse function. Thus, when the file tip reaches the predetermined point, the Automatic Apical Reverse (AAR) function stops and reverses rotation. This feature enables the controlled instrumentation in the canal's apical portion. The AAR function can be adjusted to indicate whether to set the file closer to or farther away from the apical constriction. The "0.5 mm" point on the AAR function has been set to represent the location of the apical constriction (AC), and the "APEX mark" represents the tip of the file at the apical foramen. This also eliminates the requirement for visual monitoring of the EAL display.

In our study, though there was an insignificant difference, the mean working length of EAL and IAL was lower than the Actual WL in both groups. But the mean of EAL had closer values to the Actual WL in Group 2. Thus, the distance to the actual WL was the nearest when CHX was used, instead of NaOCl (Table 1, Table 2). And this is because of the different electroconductivity of irrigating solutions. So, when these electroconductive solutions are present inside the canal, the changes in electrical characteristics as the foramen is approached are minimal. Thus, the accuracy of AL may be affected by the type of irrigant used. In solutions with greater electrical conductivity, such as NaOCl solutions, WL measurements tend to be a little bit shorter. [21]

In one study, Erdemir et al. used a Tri Auto ZX and observed no significant variation in file tip position between 2.5 % NaOCl and 2% chlorhexidine gluconate. [20] According to Shin et al., measurements made while using CHX as an irrigant are the most reliable. [22] According to earlier research, the CHX group was found to be the closest to the actual length. [20] The results of this study supported our conclusion. Thus, for both apex locator measurements, the CHX group demonstrated the shortest distance to the apex compared to the NaOCl group.

Since our work was conducted in vitro, it had the intrinsic constraint that the clinical condition of the human periodontium could not be duplicated. Additionally, each root canal has a different state. Here, we developed standardized testing circumstances as an in-vitro study model, allowing us to use a larger sample size and finish the test more rapidly. Additional studies would reveal the drawbacks and benefits of more recent apex locator devices.

Conclusion

Within the limitations of this in vitro study, it can be said that both apex locators (Integrated AL and EAL) were equally accurate in detecting WL at ±0.5mm from the apex in the presence of NaOCl and CHX. When compared to the actual WL, there was no statistically significant difference between the two groups' working length measurements. According to the findings of our study, the mean working length of groups 1 and 2 in both EAL and IAL was less than the actual working length.

Acknowledgements

I would like to thank Dr Shaban Khan for constantly supporting me and helping me out with the photographic documentation.

References

1. Altenburger, M. J., Cenik, Y., Schirrmeister, J. F., Wrbas, K. T., & Hellwig, E. (2009). Combination of apex locator and endodontic motor for continuous length control during root canal treatment. *International endodontic journal*, *42*(4), 368–374.
2. Chukka, R. R., Bellam, M. D., Marukala, N. R., Dinapadu, S., Konda, N. K., & Nagilla, J. (2020). Efficiency of an Integrated Apex Locator in Determining Working Length in Various Irrigating Solutions: An *In Vivo* Study. *Journal of pharmacy & bioallied sciences*, *12*(Suppl 1), S410–S414.
3. Connert, T., Judenhofer, M. S., Hülber-J, M., Schell, S., Mannheim, J. G., Pichler, B. J., Löst, C., & ElAyouti, A. (2018). Evaluation of the accuracy of nine electronic apex locators by using Micro-CT. *International endodontic journal*, *51*(2), 223–232.
4. Cox, A. R., & Montgomerie, R. (2019). The cases for and against double-blind reviews. *PeerJ*, *7*, e6702.
5. Custer L. E. (1918). Exact Method of Locating the Apical Foramen. *The Dental register*, *72*(9), 420–425.
6. D'Assunção, F. L., Sousa, J. C., Felinto, K. C., de Medeiros, T. C., Leite, D. T., de Lucena, R. B., & de Oliveira Lima, J. (2014). Accuracy and repeatability of 3 apex locators in locating root canal perforations: an ex vivo study. *Journal of endodontics*, *40*(8), 1241–1244.
7. Ebrahim, A. K., Wadachi, R., & Suda, H. (2007). An in vitro evaluation of the accuracy of Dentaport ZX apex locator in enlarged root canals. *Australian dental journal*, *52*(3), 193–197.
8. Fan, W., Fan, B., Gutmann, J. L., Bian, Z., & Fan, M. W. (2006). Evaluation of the accuracy of three electronic apex locators using glass tubules. *International endodontic journal*, *39*(2), 127–135.

9. Herrera, M., Ábalos, C., Lucena, C., Jiménez-Planas, A., & Llamas, R. (2011). Critical diameter of apical foramen and of file size using the Root ZX apex locator: an in vitro study. *Journal of endodontics*, *37*(9), 1306–1309.
10. Herrera, M., Ábalos, C., Lucena, C., Jiménez-Planas, A., & Llamas, R. (2011). Critical diameter of apical foramen and of file size using the Root ZX apex locator: an in vitro study. *Journal of endodontics*, *37*(9), 1306–1309.
11. Jenkins, J. A., Walker, W. A., 3rd, Schindler, W. G., & Flores, C. M. (2001). An in vitro evaluation of the accuracy of the root ZX in the presence of various irrigants. *Journal of endodontics*, *27*(3), 209–211.
12. Kim, E., & Lee, S. J. (2004). Electronic apex locator. *Dental clinics of North America*, *48*(1), 35–54.
13. Kobayashi C. (1995). Electronic canal length measurement. *Oral surgery, oral medicine, oral pathology, oral radiology, and endodontics*, *79*(2), 226–231.
14. Low, J. F., Dom, T., & Baharin, S. A. (2018). Magnification in endodontics: A review of its application and acceptance among dental practitioners. *European journal of dentistry*, *12*(4), 610–616.
15. Lucena-Martín, C., Robles-Gijón, V., Ferrer-Luque, C. M., & de Mondelo, J. M. (2004). In vitro evaluation of the accuracy of three electronic apex locators. *Journal of endodontics*, *30*(4), 231–233.
16. Marek, E., Łagocka, R., Kot, K., Woźniak, K., & Lipski, M. (2019). The influence of two forms of chlorhexidine on the accuracy of contemporary electronic apex locators. *BMC oral health*, *20*(1), 3.
17. Mello, I., Michaud, P. L., & Tanner, N. (2020). Resistance to fracture of extracted teeth used for pre-clinical endodontic procedures: Influence of storage conditions. *European journal of dental education: official journal of the Association for Dental Education in Europe*, *24*(2), 272–275.
18. Meza, M. I. Z., Veliz, E. A. R., Mendoza, C. A. V., Delgado, R. A. C., & Ormaza, G. F. (2018). Comparison of studies through laboratory tests to loan material (ballast) of San Jose and AGRE S.A. quarries treated with asphalt emulsion or cement. *International Journal of Physical Sciences and Engineering*, *2*(2), 50–67. https://doi.org/10.29332/ijpse.v1n2.146
19. Oishi, A., Yoshioka, T., Kobayashi, C., & Suda, H. (2002). Electronic detection of root canal constrictions. *Journal of endodontics*, *28*(5), 361–364.
20. Rakhmonov, O. M., Shadmanov, A. K., & Juraev, F. M. (2021). Results of endoscopic treatment of benign prostatic hyperplasia in patients with metabolic syndrome. *International Journal of Health & Medical Sciences*, *5*(1), 21-25. https://doi.org/10.21744/ijhms.v5n1.1811
21. Rathore, K., Tandon, S., Sharma, M., Kalia, G., Shekhawat, T., & Chundawat, Y. (2020). Comparison of Accuracy of Apex Locator with Tactile and Conventional Radiographic Method for Working Length Determination in Primary and Permanent Teeth. *International journal of clinical pediatric dentistry*, *13*(3), 235–239.
22. Secilmis A., Dilber E., Gokmen F., Ozturk N., Telatar T. (2011). Effects of Storage Solutions on Mineral Contents of Dentin, Journal of Dental Sciences 6(4), 189-194.
23. Shin, H. S., Yang, W. K., Kim, M. R., Ko, H. J., Cho, K. M., Park, S. H., & Kim, J. W. (2012). Accuracy of Root ZX in teeth with simulated root perforation in the presence of gel or liquid type endodontic irrigant. *Restorative dentistry & endodontics*, *37*(3), 149–154.

24. Sivakumar S., Thangavel B., Sekar M., (2021) Apical Reference Point – A Clinical Perspective. J Acad Dent Educ ,7(1),2-5.
25. Widana, I.K., Sumetri, N.W., Sutapa, I.K., Suryasa, W. (2021). Anthropometric measures for better cardiovascular and musculoskeletal health. *Computer Applications in Engineering Education*, *29*(3), 550–561. https://doi.org/10.1002/cae.22202