Section A-Research paper

Comparative evaluation of accuracy of fifth and sixth generation electronic apex locators in the presence of three different irrigating solutions in working length determination: An in vitro single blinded study.

Dr. Pooja Hene, Dr. Swapnil Kolhe, Dr. Meenal Gulve, Dr. Surbhi Patel, Dr. Priyanka kolhe, Dr. Rohini Karad.

Post Graduate Student[1], Professor[2], Head of Department[3], Associate Professor[4], Associate Professor[5], Senior Lecturer[6].

Address for correspondence:

Department of conservative dentistry and endodontics, MGV'S KBH dental college and hospital, Nashik, Maharashtra, India

Pooja Hene

MGV'S KBH Dental College and Hospital, Mumbai Agra Road, Panchvati, Nashik, Maharashtra -422003.

E- mail- hene.pooja@gmail.com.

ABSTRACT-

Aim- To compare and evaluate accuracy of fifth and sixth generation electronic apex locators in the presence of three different irrigating solutions in working length determination.

Material and methods: 30 extracted human mandibular premolars were used. The crowns were cut horizontally and access cavity preparation was prepared. Working length were evaluated by three methods: Group I: control group (visible method, n=30), Group II: fifth generation apex locator (n=30), Group III: sixth generation apex locator (n=30). In control group, the root canal length were measured under stereomicroscope under 10X magnification upto apical foramen and distance were measured with digital caliper and 0.5 mm was deducted from this canal length. Group II and III were further divided into 3 subgroups based on irrigating solutions: Group A: saline (n=30), Group B: 5.25% NaOCl (n=30), Group C: 17% EDTA (n=30). Teeth were embedded in alginate mass along with metal lip clip to complete the current circuit. Teeth were irrigated with three different irrigating solutions according to three subgroups. Root canal length were taken on apex locator upto apical foramen. Then, working length were measured with a digital caliper and 0.5 mm were deducted from this length. For each tooth and the type of irrigant, three measurements were made and the mean of measurements were taken.

Statistical analysis: One way Analysis of Variance (ANOVA) test was performed for intergroup comparison, followed by post hoc test.

Result: There is significant difference seen between Group I (control) and group III (6^{th} generation) However these values can be clinically acceptable. In case of irrigating solution used in this study least effect on accuracy was shown by normal saline followed by 17% EDTA and 5.25% NaOCI

Conclusion: electronic apex locators can be used to measure the working length, even in the presence of irrigating solutions. There was difference in accuracy of 5^{th} and 6^{th} generation EALs than the actual WL which is within clinically acceptable range.

Key words: Electronic Apex locator (EAL), chlorhexidine (CHX), ethylenediaminetetraacetic acid (EDTA), root canal irrigant, sodium hypochlorite, working length.

INTRODUCTION:

Correct determination of working length in endodontic treatment is a key factor that can influence the outcome of root canal[1]. Cemento-Dentinal Junction (CDJ) is the correct apical limit for root canal treatment as at this level the contact between the periradicular tissues and root canal filling material is likely to be minimal[2]. CDJ is a histological landmark and in clinical situation it is impossible to identify its location. Therefore, CDJ is not an ideal landmark for apical end-point of root canal preparation and filling. In clinical practice, the apical constriction is a consistent anatomical feature which is narrowest portion of the canal system and thus preferred for the apical end-point for root canal treatment. However, it is generally accepted that the apical constriction is located 0.5-1.0 mm short of the radiographic apex, there are variations in the relationship of these landmarks[3].

The use of electronic devices to determine the working length was first proposed by Custer[4] and the scientific basis of apex locators was given by Suzuki[5]. After that devices became more sophisticated and have used the characteristics of impedance gradients and frequency dependency to provide more accurate measurements in clinical conditions. The new electronic apex locators (EALs), in which the problems with wet canal have been solved, include third-generation apex locators that use single frequencies, fourth-generation apex locators that use two separate frequencies, and fifth-and sixth-generation devices that use multiple frequencies to measure working length. Thus, leads to proper mechanical debridement of the root canals.[6] I- ROOT (S-Denti SEoul, south korea) is fifth generation electronic apex locator. CanalPro (ColteneEndo) is sixth generation electronic apex locator. CanalPro apex locator offers 3D interface with high resolution color graphic display.

Irrigation is the best method for the removal of tissue and dentine debris during instrumentation. Many materials have been used in the root canal irrigation like sodium hypochlorite (NaOCl), ethylenediaminetetraacetic acid (EDTA) and chlorhexidine gluconate which are the most popular and reliable solutions. Due to their wide spectrum antimicrobial activity, an irrigation regimen has been proposed, in which NaOCl would be used throughout instrumentation, followed by EDTA as a final irrigant[6].

MATERIAL AND METHODS:

Thirty freshly extracted human mandibular premolar teeth were obtained from department of oral and maxillofacial surgery of college. Included teeth were mandibular premolar teeth with mature apex and single-root. Teeth with any restorations, fracture, open apex, resorption, calcified roots and root canal treated teeth were excluded.

Method of specimen preparation:

Thirty Intact, mature human mandibular premolars were selected. All teeth were radiographed mesiodistally and labiolingually using RVG to eliminate teeth with restorations, caries, root cracks, fractured roots, internal or external resorptions, calcified canals, more than one canal, and canal curvatures >20°. Cusps tips of the included teeth were flattened with a cylindrical diamond bur to create a stable and reliable coronal reference point. The access cavity in each selected teeth were made with a spherical diamond bur.

Working length were evaluated by three methods as follows:

Group I: control group (visible method) (n=30)

Group II: fifth generation apex locator (n=30)

Group III: sixth generation apex locator(n=30)

Actual working length measurement:

In control group, the root canal length was measured by introducing a size 15 K-file into the canal until the tip of the file became visible at the apical foramen under stereomicroscope under 10X magnification. The silicon stop was then carefully adjusted to the reference level and the distance between the base of the silicon stop and the file tip was measured using a digital caliper. Working length was established by subtracting 0.5 mm from this measured length.[6]

Electronic working length measurement:

Group II and III was further divided into 3 subgroups based on irrigating solutions.

Group A: saline (n=30)

Group B: 5.25% NaOCl(n=30)

Group C: 17% EDTA(n=30)

Then, teeth were embedded up to the CEJ in an alginate mass, which was prepared according to the manufacturer's instructions and poured into a plastic container. For every tooth, a new alginate mass was prepared. A metal lip clip was also placed into the alginate mass to complete the current circuit. The measurements were performed in the moist alginate mass, i.e., within 15–20 min for one tooth. Teeth were irrigated with three different irrigating solutions according to three subgroups.

Irrigation was performed into the canal using an irrigation syringe and 0.3 mm (30 G) needle. Each canal was irrigated with 2 ml of irrigant, and the excess fluid was dried with

a paper point. All measurements were made directly after placement of the irrigant into the canal. Then the apex locator was turned on #15 K file was inserted into canal which was slowly advanced apically into the canal until "0.0" appeared on the screen, then file was slightly pulled out until the apex locator showed the "0.5 mm" reading. Then rubber stop on the file was set to the reference point. If the measurement remained constant for 5s, the file was withdrawn carefully and the distance between the rubber stop and the tip of the file was measured with a digital caliper and 0.5 mm was deducted from this length which were recorded [6,8,9] For each tooth and the type of irrigant, three measurements were made and the mean of these measurements was be taken as the reading.

Statistical analysis:

Statistical analysis were performed using Statistical Package for Social science (SPSS) version 21 for Windows (SPSSInc Chicago, IL). Descriptive quantitative data was expressed in mean and standard deviation. Overall intergroup comparison among three groups was be done using One-way Anova 'F' test followed by Tukey's post hoc test for pairwise intergroup comparison between each group.

Results:

Table 1: Descriptive statistics of mean (SD) of fifth and sixth generation electronic apex locator with actual working length in presence of three different irrigating solutions in working length determination.

Subgroups	Group I (control) Mean (SD)	Group II (5^{th} gen EAL) Mean (SD)	Group III (6^{th} gen EAL) Mean (SD)
Subgroup A (saline)	18.983 (0.444)	18.536 (0.491)	18.291 (0.512)
Subgroup B (NaOCI)	18.983 (0.444)	18.243 (0.494)	18.106 (0.430)
Subgroup C (EDTA)	18.983 (0.444)	18.350 (0.440)	18.226 (0.461)

Table 2 : Comparison of mean discrepancy of fifth and sixth generation electronic apex locator in presence of three different irrigating solutions in working length determination from control group in all subgroups

Discrepancy from group I (control)	Group II (5^{th} Generation EAL) Mean (SD)	Group III (6^{th} Generation EAL) Mean (SD)	Unpaired 't' test	P value, Significance
subgroup A (Saline)	0.444 (0.14)	0.693 (0.09)	t = 7.876	p =0.003*
subgroup B (Hypochlorite)	0.744 (0.08)	0.876 (0.17)	t = 3.834	p =0.012*
subgroup C (17%EDTA)	0.633 (0.11)	0.756 (0.12)	t = 3.877	p= 0.008*

***p<0.001 – statistically significant difference**

Table 3: Intrgaroup comparison of mean discrepancy of fifth generation electronic apex locator in presence of three different irrigating solutions in working length determination from control group in all sub- groups

Discrepancy from control group (group I) In 5th genereation EAL (Group II)	Mean	SD	One way Anova F test	P value, Significance
subgroup A (Saline)	0.446	0.14	F = 47.42	P < 0.001**
subgroup B (Hypochlorite)	0.74	0.08		
subgroup C (17%EDTA)	0.633	0.11		
Tukey's post hoc test to find pairwise comparison				
Group	Comparison Group		Mean Difference	p value, Significance
subgroup A (Saline) vs	subgroup B (Hypochlorite)		0.29	P < 0.001**
	subgroup C (17%EDTA)		0.18	P < 0.001**
subgroup B (Hypochlorite) vs	subgroup C (17%EDTA)		0.10	p =0.002*

*p<0.05 – significant difference **p<0.001 – highly significant difference

Table 4: Intrgaroup comparison of mean discrepancy of sixth generation electronic apex locator in presence of three different irrigating solutions in working length determination from control group in all sub- groups

Discrepancy from control group (group I) In 6th generation EAL (Group III)	Mean	SD	One way Anova F test	P value, Significance
Subgroup A (Saline)	0.693	0.09	F = 13.917	p < 0.001**
Subgroup B (Hypochlorite)	0.876	0.177		
Subgroup C (17%EDTA)	0.756	0.127		
Tukey's post hoc test to find pairwise comparison				
Group	Comparison Group		Mean Difference	p value, Significance
Subgroup A (Saline) vs	Subgroup B (Hypochlorite)		0.18	p < 0.001**
	Subgroup C (17%EDTA)		0.06	p =0.178 (ns)
Subgroup B (Hypochlorite) vs	Subgroup C (17%EDTA)		0.12	p =0.051 (ns)

*p<0.05 – significant difference **p<0.001 – highly significant difference

Among experimental groups, there is no statistically significant difference seen between Group I control group (Mean=18.983 ±0.444) and group II (5^{th} generation EAL) but group III (6^{th} generation EAL) showed significant difference with group I and Group II, However these were within the clinically acceptable range.

When the influence of different irrigating solutions on the accuracy of EALs were evaluated, it was observed that subgroup A (saline) had the least effect and subgroup C (EDTA) and subgroup B (NaOCI) had significantly more effect on the accuracy of EAL

DISCUSSION:

Accurate measurement of working length is the most important step in the root canal treatment for successful endodontic treatment. An alginate model was used in this study[10] as it has electrical impedance that imitates the human periodontium, can be used for in vitro assessments of EALs and can also be used with any irrigation solution[11].

In the present study i-Root (S-Denti, Seoul, Korea) 5^{th} generation apex locator show more accuracy than CanalPro® Apex Locator, 6^{th} generation apex locator when compared with actual length. i-root EAL can determine the root canal working length with high precision and greater predictability[12]. i-Root (S-Denti, Seoul, Korea) is a fifth generation EAL which uses multiple frequencies for accurate detection of the apical constriction. I-Root was developed and upgraded based on the technology of e-Magic finder (EMF - 100 Series) apex locator. I-Root's unique patient management system (PMS) helps to measure the working length on the computer monitor, recording it in the database and printing the same if necessary[12]. CanalPro® Apex Locator uses multiple frequency and uses steady algorithm for adapting the method for WL measurement depending on canal moisture. As it is based on steady algorithm it may produce average working length while i-Root apex locator produce accurate working length.

New-generation EALs can work accurately in the presence of various electrolytes. However, there is still a doubt whether electro-conductive irrigants such as blood, saline, anesthetic solution, irrigants can affect the accuracy of the EAL performance.[13] However, the presence of any fluid or irrigant may obstruct the use of apex locators and obtaining accurate measurements. The effects of various irrigants on EAL performance have been studied. Numerous studies indicate that endodontic measurement can be performed in the presence of conductive fluid, but the type of irrigant solution can affect the accuracy of the EAL. In the present study the influence of different irrigating solutions on the accuracy of EALs were evaluated, it was observed that subgroup A (saline) had the least effect and subgroup C (EDTA) and subgroup B (NaOCI) had significantly more effect on the accuracy of EAL.[14,6]

6^{th} generation EAL was affected by presence of different irrigating solutions. Also NaOCl affect accuracy of apex locator as it has higher electroconductivity than EDTA and saline. NaOCl is a solution characterized by high electrical conductivity and has a potential to penetrate into dentinal tubules and decrease the electrical impedance of the root canal walls as well as generate better electrical contact with periapical tissues [16,17].

NaOCl is the most conducting endodontic solution.[17] The conductivity of root canal irrigants from most to least are as following. 5.25% NaOCl solution, 17% EDTA solution, 2% chlorhexidine, normal saline and finally RC-prep, and 70% isopropyl alcohol.[18]

CONCLUSION:

EAL can be used to accurately measure the working length, even in the presence of irrigating solutions. There was difference in accuracy of 5^{th} and 6^{th} generation EALs than the actual WL but these were within clinically acceptable range. In case of irrigating solutions used in the study, the least effect on the accuracy of EAL was seen with normal saline followed by 17% EDTA and 5.25% NaOCl.

ACKNOWLEDGEMENT:

The authors are indebted to the staff members of Shanmukh Laboratory, Nashik, Maharashtra, India for facilitating the use of the stereomicroscope.

REFERENCES:

1. Nguyen HO, Kaufman AY, Komorowski RC, Friedman S. Electronic length measurement using small and large files in enlarged canals. Int Endod J. 1996 Nov;29(6):359-64.
2. Ricucci D. Apical limit of root canal instrumentation and obturation, part 1. Literature review. Int Endod J 1998;31:384-93.
3. Katz A, Tamse A, Kaufman AY. Tooth length determination: A review. Oral Surg Oral Med Oral Pathol 1991;72:238-42.
4. Custer LE. Exact methods of locating the apical foramen. J N Dent Assoc 1918;5:815-9.
5. Suzuki K. Experimental study on iontophoresis. J Stomatol Soc (Japan) 1942;16:411-7.
6. Jha P, Nikhil V, Raj S, Ravinder R, Mishra P. Accuracy of electronic apex locator in the presence of different irrigating solutions. Endodontology 2021;33:232-6.
7. Taneja S, Kumar M, Sharma SS, Gogia H, et al. Comparative Evaluation of Accuracy of Three Electronic Apex Locators in Different Simulated Clinical Conditions- An invitro Study. Ann Med Health Sci Res. 2017; 7: 190-194.
8. Marek E, Łagocka R, Kot K, Woźniak K, Lipski M. The influence of two forms of chlorhexidine on the accuracy of contemporary electronic apex locators. BMC Oral Health. 2019;20(1):3.
9. 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.

10. Kaufman A.Y., Keila S., Yoshpe M.: Accuracy of a new apex locator: an in vitro study. Int Endod J;35:186 –92, 2002.
11. Kaufman A.Y., Katz A.: Reliability of Root ZX apex locator tested by an in vitro model. J Endod; 19:201,
12. Sakkir N, Asifulla M, Chandra V, Idris M, Razvi SF, Geeta IB. In vitro evaluation of the accuracy of five different electronic apex locators. Saudi Endodontic Journal. 2015 Sep 1;5(3):177.
13. Kim E, Lee SJ. Electronic apex locator. Dent Clin North Am 2004;48:35-54
14. 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.
15. 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 Jan 25;1:103.
16. EbrahimAK, Yoshioka T, Kobayashi C, Suda H. The effects of file size, sodium hypochlorite and blood on the accuracy of root ZX apex locator in enlarged root canals: An in vitro study. Aust Dent J 2006;51:153-7.
17. Pilot TF, Pitts DL. Determination of impedance changes at varying frequencies in relation to root canal file position and irrigant. J Endod 1997;23:719-24.
18. Biradar B, Biradar S, Tandan M, Godara N, Arvind MS, Byakod P. Evaluation of influence of instrument size on the accuracy of three different apex locators in the presence of different irrigation solution in vital teeth: An in vivo study. Int J Sci Res 2020;9:75-8.
19. Srivastava V, Jain N, Bagchi S, Negi MP. Evaluation of the use of sixth generation apex locators as a diagnostic tool to detect root perforations. International Journal of Dental and Medical Specialty. 2015 Oct 1;2(4):10.
20. Elsewify T. Influence of irrigants on accuracy of iPex II and DentaPort ZX in working length determination. Egyptian Dental Journal. 2018 Jul 1;64(3-July (Fixed Prosthodontics, Dental Materials, Conservative Dentistry & Endodontics)):2827-32.
21. Bilaiya S, Patni PM, Jain P, Pandey SH, Raghuwanshi S, Bagulkar B. Comparative Evaluation of Accuracy of Ipex, Root Zx Mini, and Epex Pro Apex Locators in Teeth with Artificially Created Root Perforations in Presence of Various Intracanal Irrigants. Eur Endod J 2020; 1: 6-9
22. Diemer, F. Plews, E. Georgelin-Gurgel, M. Mishra, L. Kim, H.-C. Effect of Sodium Hypochlorite Concentration on Electronic Apex Locator Reliability. Materials 2022, 15, 863.