Original Article

Comparative evaluation of accuracy of working length determination with fifth-generation apex locator using two different techniques: An *in vitro* study

Monisha R, Andamuthu Sivakumar, Chittrarasu M, Sivakumar Jambai Sampath, Saravana Priyan Soundappan, Reveena Benny

Department of Conservative Dentistry, Vivekanandha Dental College for Women, Tiruchengode, Tamil Nadu, India

Downloaded from http://journals.lww.com/jcde by BhDMf5ePHKav1zEoum1tQfN4a+kJLhEZgbsIHo4XMi0hCywCX1AWnYQp/IlQrHD3i3D0OdRyi7TvSFl4Cf3VC1y0abggQZXdgGj2MwlZLeI= on 03/12/2024

Abstract

Context: Accurate working length (WL) determination is essential for successful root canal therapy.

Aim: The aim of this study was to compare the difference between two different techniques in locating minor constriction using fifth-generation electronic apex locator.

Settings and Design: A detailed protocol explaining the procedures of the study was submitted to the institutional ethics committee.

Subjects and Methods: Forty extracted human permanent canine teeth were selected. WL was measured three times for each sample by three different examiners for both the conventional and experimental techniques at different time intervals. Interexaminers were blinded to their measurements, and the person who analyzed mean value was also blinded with techniques. Finally, radiographic working length was obtained using 15 size K-file. A size 20 K-file was cemented into the measured position with glass ionomer cement. Each tooth was viewed under a stereomicroscope at ×40 magnification. The distance from the file tip to the root apex was measured and calibrated to the nearest tenth of a millimeter.

Statistical Analysis Used: Using Stata statistical software (Version 17, Statacorp, College Station, Texas, USA). The agreement between raters and techniques was determined using intraclass correlation coefficient "ICC" and Bland–Altman plot.

Results: The "experimental method" (0.95, 95%) showed better agreement between the raters in comparison with the "conventional method" (0.93, 95%).

Conclusions: The experimental technique showed perfect agreement between examiners in locating the minor constriction of the apical foramen.

Keywords: Conventional and experimental techniques; electronic apex locator; working length

INTRODUCTION

Successful endodontic treatment comprises thorough debridement of pulpal tissue, ritual cleaning and shaping, and three-dimensional obturation of the root canal.[1] The significant part of root canal treatment (RCT) is canal

Address for correspondence:
Dr. Andamuthu Sivakumar,
3/20 Ayyan kudil, Appichimarmadam, Thingalur(P.O),
Perundurai(T.K), Erode - 638 055, Tamil Nadu, India.
E-mail: tirupurdental@gmail.com

Date of submission : 06.10.2023
Review completed : 15.11.2023
Date of acceptance : 05.12.2023
Published : 06.03.2024

Access this article online

Quick Response Code:

Website: https://journals.lww.com/jcde

DOI: 10.4103/JCDE.JCDE_210_23

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: WKHLRPMedknow_reprints@wolterskluwer.com

How to cite this article: Monisha R, Sivakumar A, Chittrarasu M, Sampath SJ, Soundappan SP, Benny R. Comparative evaluation of accuracy of working length determination with fifth-generation apex locator using two different techniques: An *in vitro* study. J Conserv Dent Endod 2024;27:240-5.

Downloaded from http://journals.lww.com/jcde by BhDMf5ePHKav1zEoum1tQfN4a+kJLhEZgbsIHo4XMi0hCywCX1AWnYQp/IlQrHD3i3D0OdRyi7TvSFl4Cf3VC1y0abggQZXdgGj2MwlZLeI= on 03/12/2024

preparation which can be achieved successfully by correct determination of the working length (WL).[2]

The endodontic glossary defines WL as "the distance from a coronal reference point to a point at which the canal preparation and obturation should terminate."[3] Cementodentinal junction (CDJ) or apical constriction represents the transition between the pulpal and periodontal tissues.[4-6]

Despite radiographs being the key method of determining WL, there are several factors influencing their accuracy in locating canal constriction.[7,8] Sunada (1962) stated that electrical resistance between the periodontal ligament and oral mucosa remains unchanging; modern electronic apex locators (EALs) are used for locating minor constriction of canal.[7,9,10]

Fifth-generation EALs have a measuring method with additional mathematical processing which is harmless, trustability, and beneficial to clinician.[9,11] Two techniques were used to determine the WL. The rationale of the experimental technique was to determine the accurate WL without disturbing the silicone stopper and to prevent the underestimation or overestimation. The advantage of the experimental technique was to determine accurate WL, whereas the placement of the file holder will not displace the stopper in case of limited accessibility (restricted mouth opening) with longer root canals. The purpose of the study is to evaluate the accuracy of locating the minor constriction of apical foramen in the root canal of extracted permanent maxillary canine using conventional and experimental techniques.

SUBJECTS AND METHODS

A detailed protocol explaining the purpose and procedures of the study was submitted to the institutional ethics committee, and ethical clearance was obtained.

Forty extracted human permanent maxillary canines with closed apices were collected. Restored, fractured, and cavitated were excluded from the study. All teeth were cleaned using curettes, and distilled water was used as a storage medium until use. Access opening and coronal flare-up were done. The patency of the canal was gained by using a size 10 K-file.

Apex locator was connected in the experimental setup where teeth and the lip clip were placed in the saline to mimic the oral environment. WL determination using the conventional technique was done in all the samples by passing 15 size K-file into the canal until the EAL indicated that minor foramen had been reached. For all the samples, WL was determined using the experimental technique, where A size 15 K-file was passed into the canal. Another 10 or 15 size K-file was attached to the file holder of the Apex Locator and placed it over the file which was inserted into the canal. Proper contact between two files was maintained until Apex Locator indicated [Figure 1]. The silicone stopper was carefully adjusted to the coronal reference plane. The distance between the tip of the file and the silicone stopper was measured to the nearest tenth of a millimeter by three different examiners.[10] In the experimental technique, the chances of dislodgment of the silicone stopper were greatly reduced because the diameter of the file holder was too large when compared to that of diameter of 15 K-file. At the level of coronal reference point, where the placement of file holder, i.e., the conventional technique will misplace the silicone stopper eventually, leading to the inappropriate measurement of the root canal in case of restricted accessibility.

The examiners consisted of three second-year endodontic postgraduate students. Sufficient training and guidance were given to all the examiners for 1 week to evaluate WL using both techniques. The measurements of all the samples were recorded to the nearest tenth of a millimeter.

Finally, WL assessment was done using the radiographic method. A size 15 K-file was passed into the canal until the tip of the file is visible at the level of apical foramen and then subtracting 0.5 mm to locate the minor constriction of the canal. The silicone stop was adjusted, and WL was measured. After the length was determined, a size 20 K-file was cemented in place using glass–ionomer cement to prevent the dislodgment of the file and to maintain the measured WL and gain more stability which facilitates easy placement and subsequent evaluation under magnification.[10]

The stereomicroscopic evaluation was done under ×40 magnification. If the file tip was seen beyond the apex, there was no need to modify it, and the distance between

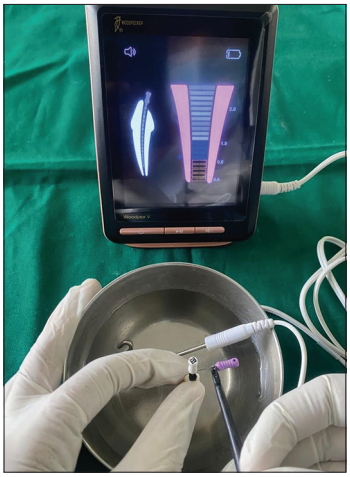


Figure 1: Experimental technique for working length determination

Downloaded from http://journals.lww.com/jcde by BhDMf5ePHKav1zEoum1tQfN4a+kJLhEZgbsIHo4XMi0hCywCX1AWnYQp/IlQrHD3i3D0OdRyi7TvSFl4Cf3VC1y0abggQZXdgGj2MwlZLeI= on 03/12/2024

the file tip and apex was measured by placing a scale under the tooth [Figure 2]. If the file tip was short of the apex, then the lateral surface of the apex was shaved using finishing carbide bur until the tip of the file was visible under ×2.5 magnifying loupes. Then, it is subjected to stereomicroscopic evaluation to evaluate the distance between the file tip and the most coronal aspect of the major foramen [Figure 3].[5]

The statistical analysis was performed using Stata Statistical Software (Version 17, Statacorp, College station, Texas, USA). The agreement between the raters of a particular method for measuring WL was determined using intraclass correlation coefficient "ICC." The Bland–Altman plot was generated to determine the agreement between "stereoscopic measurement" (reference standard) with the other methods ("radiographic method," "conventional method," and "experimental method").

Lin's concordance coefficient was computed to determine how far the observed variables deviate from the line of perfect agreement ([i.e.,] measures both accuracy and precision). Pearson's correlation coefficient "r" measures "precision." C_b measures the "the degree of accuracy." The "Bradley–Blackwood F statistic" was computed to test "equality of means and variances" between the assessed methods and "stereoscopic measurement" (reference standard). Nonsignificant *P* values imply better concordance.

RESULTS

The "experimental method" (0.95, 95% confidence interval [CI]: 0.92–0.97) showed better agreement with the raters in comparison with the "conventional method" (0.93, 95% CI: 0.88–0.96) [Table 1]. The "Bland–Altman plot" showed the bias factor for "conventional method" to be −0.425 (95% limits of agreement: −2.049 and 1.199) for the first rater, −0.475 (95% limits of agreement: −2.179, 1.229) for second rater, and − 0.188 (95% limits of agreement: −1.688, 1.313) for third rater [Graph 1].

It also showed the bias factor for "experimental method" to be −0.275 (95% limits of agreement: −1.890, 1.340) for the first rater, −0.450 (95% limits of agreement: −1.814, 0.914) for second rater, and −0.125 (95% limits of agreement: −1.610, 1.360) for third rater [Graph 2]. The bias factor for "radiographic method" was determined to be −0.350 (95% limits of agreement: −1.648, 0.948) [Graph 3], and radiographic WL (RWL) (has a constant value) was determined by one examiner.

Higher "Lin's concordance coefficient" was observed for "experimental method" for all the raters (first rater: 0.92, 95% CI = 0.87–0.97, second rater: 0.93, 95% CI = 0.89–0.97, and third rater: 0.94, 95% CI = 0.90–0.98) in comparison with "conventional method which implies better concordance with "stereoscopic measurements." The "Bradley–Blackwood F statistic" showed that "conventional technique measurements" performed by third rater (*P* = 0.31779) and "experimental technique measurements" performed by first (*P* = 0.08343) and third rater (*P* = 0.54265) had better concordance with "stereoscopic measurements [Table 2]."

DISCUSSION

Endometrics, the science of determining WL in endodontics, holds high significance in the success of endodontic therapy.[12,13] The importance of WL is,

- Determines how far the instrument is inserted into the canal
- Affects the degree of pain and discomfort by virtue of over or under-instrumentation
- Plays an essential role in determining the success of treatment
- When WL is short of the root apex will eventually lead to apical leakage.[2]

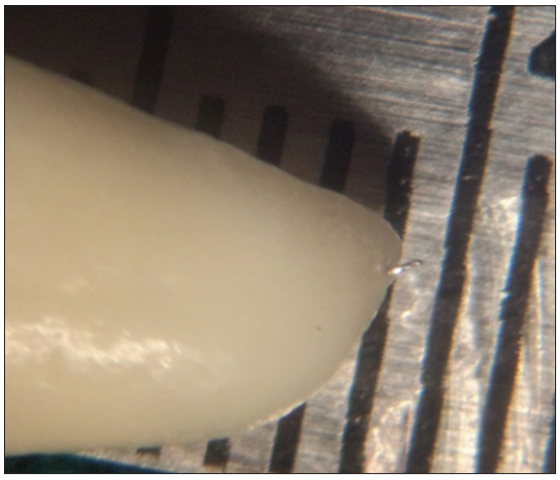


Figure 2: File was seen beyond the apex

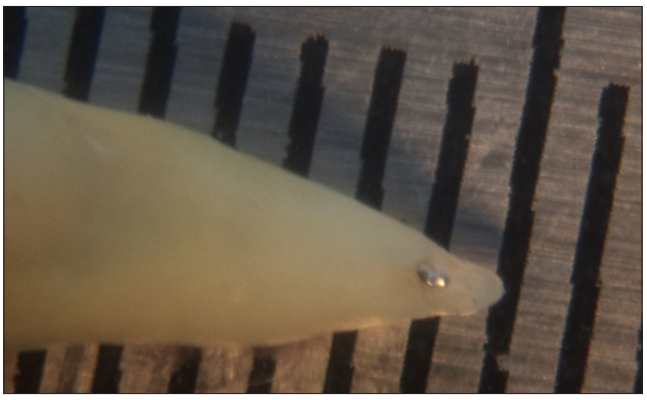
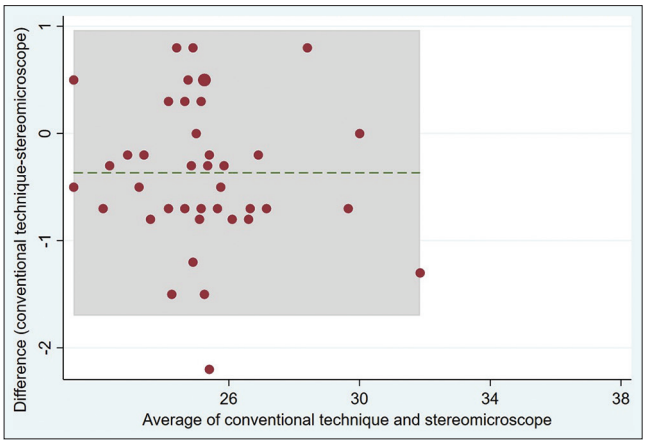
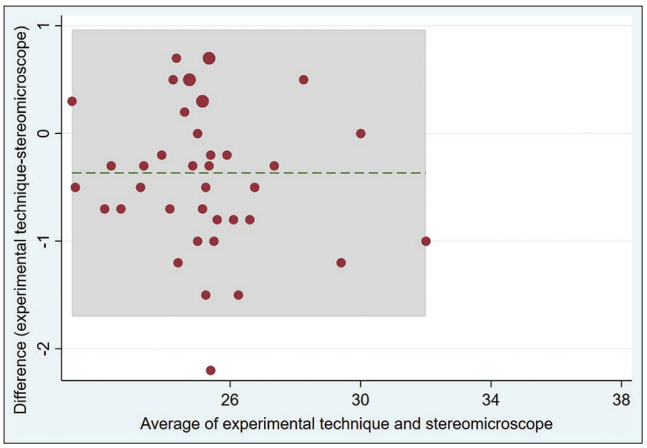


Figure 3: File was seen short of the apex

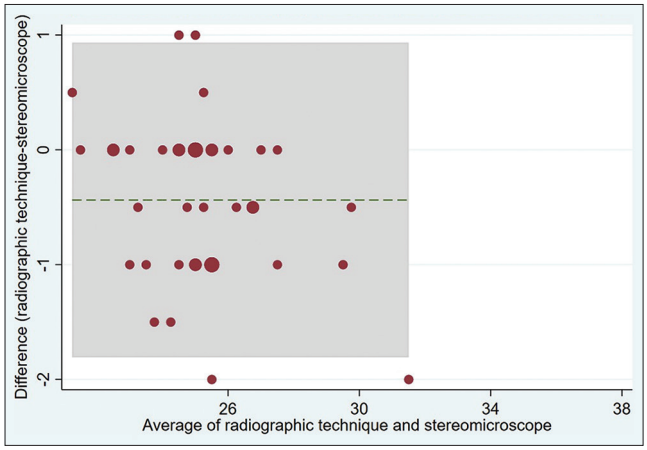
Downloaded from http://journals.lww.com/jcde by BhDMf5ePHKav1zEoum1tQfN4a+kJLhEZgbsIHo4XMi0hCywCX1AWnYQp/IlQrHD3i3D0OdRyi7TvSFl4Cf3VC1y0abggQZXdgGj2MwlZLeI= on 03/12/2024



Graph 1: Agreement between the conventional technique and stereomicroscope



Graph 2: Agreement between the experimental technique and stereomicroscope



Graph 3: Agreement between the radiographic technique and stereomicroscope

WL beyond the minor diameter, i.e., overinstrumentation beyond the root apex that can lead to postoperative pain and long-term failure. WL short of the minor diameter, i.e., underestimation of WL leads to insufficient cleaning.[5,6]

Table 1: Intraclass correlation coefficient between raters for different techniques

Technique	ICC	95% CI
Conventional technique	0.926	0.88–0.958
Experimental technique	0.953	0.921–0.974

ICC: Intraclass correlation coefficient, CI: Confidence interval

The apical endpoint of the canal is to be the CDJ which represents the transition between the pulpal and periodontal tissues.[14]

Hembrough *et al*. stated that the radiographs are an indispensable aid in WL determination[15] and have limitations of distortion, shortening, and elongation.[10] Because of the lack of three-dimensional representation of the canal, RWL becomes more questionable other methods of WL determination become necessary. EAL also called as electronic root canal length measuring device is an electronic device is to determine the position of apical constriction[4] on the basis of electrical properties of tooth-like resistance, impedance, and capacitance.[10]

Vieyra *et al*. stated locating the minor foramen using a conventional technique by two EALs was more accurate than radiographs.[10]

The four meta-analyses of the 15 studies among the third, fourth, fifth, and sixth generations showed that there was no significant difference in the accuracy of EALs.[16]

Swapna *et al*.[17] and Singh and Kapoor[13] concluded that Raypex 5 was reliable. Somma *et al*. compared the accuracies of Raypex 5, ProPex II, and DentaPort ZX and concluded Raypex 5, i.e., fifth-generation EAL was accurate.[18] In the present study, fifth-generation EAL, i.e., Woodpex V, Guilin Woodpecker Medical Instrument Co., LTD., was used to determine the WL.

Thomas *et al*. (2003) found both SS and NiTi files show similar accuracy using EALs. The accuracy of electronic WL length determination with SS files in various study ranges from 70% to 100%.[19] Nguyen *et al*. suggested that the electronic WL determination was not influenced by the size of the file used and concluded that in an enlarged canal of size up to 60, a file matching the diameter of the canal (size 60) and a considerably smaller file (size 10) similar measurements.[7,20]

The accuracy of EALs decreases as the file size increases. Sadeghi (2008) suggested that size 15 K-file is a more suitable size for determining WL.[1,21] Hence, in our study, size 15 SS K-file was used to determine WL, and also we evaluated the WL accuracy in maxillary canine because of its longest root where the chances of misplacement of the stopper were high which will lead to inappropriate measurement.

Table 2: Concordance of different techniques with stereomicroscopic measurements

Technique (n=40)	Mean Bias	SD	95% limits of agreement (Bland–Altman, 1986)	Accuracy C_b=rho_c/r	Precision Pearson's r	Lin's concordance correlation coefficient (Lin 1989, 2000)	Bradley-Blackwood F statistic*
Conventional technique operator 1 bias (n=40)	−0.425	0.8286	−2.049, 1.199	0.980	0.928	0.909 (95% CI=0.856–0.963)	F=5.331, P=0.00910
Conventional technique operator 2 bias (n=40)	−0.475	0.8693	−2.179, 1.229	0.977	0.922	0.900 (95% CI=0.842–0.959)	F=5.831, P=0.00619
Conventional technique operator 3 bias (n=40)	−0.188	0.7653	−1.688, 1.313	0.996	0.939	0.936 (95% CI=0.897–0.975)	F=1.182, P=0.31779
Experimental technique operator 1 bias (n=40)	−0.275	0.8195	−1.890, 1.340	0.990	0.928	0.919 (95% CI=0.870–0.967)	F=2.653, P=0.08343
Experimental technique operator 2 bias (n=40)	−0.450	0.6622	−1.814, 0.914	0.978	0.949	0.928 (95% CI=0.885–0.970)	F=8.555, P=0.00086
Experimental technique operator 3 bias (n=40)	−0.125	0.7663	−1.610, 1.360	0.998	0.940	0.938 (95% CI=0.900–0.976)	F=0.621, P=0.54265
Radiographic technique (n=40)	−0.350	0.6620	−1.648, 0.948	0.984	0.954	0.939 (95% CI=0.903–0.975)	F=6.601, P=0.00346

*Insignificant P values for Bradley-Blackwood F statistic signify better concordance. SD: Standard deviation, CI: Confidence interval

In our study, an experimental technique is used to determine the accuracy of WL. To the best of our knowledge, none of the other authors explained this experimental technique. The purpose of this experimental technique is to determine the WL without disturbing the silicone stopper which was helpful to measure the exact WL and to avoid underestimation/overestimation of WL which may lead to failure of the RCT procedure.

Hoer and Attin, concluded that the WL determination should be carried out using a combination of an EAL and radiograph.[8] To overcome the false readings of EAL, RWL is necessary.[5] Williams *et al*. suggest that radiographs are a useful adjunct in the establishment of an appropriate WL.[5] Hence, in our study, the RWL was taken and used as an adjuvant reference WL of the canal.

In our study to reduce bias in the estimation of WL for both techniques, three examiners were chosen. All the three examiners were selected with the same qualifications and experiences, i.e., second-year endodontic postgraduate students. Sufficient training and guidance were given to all the three examiners for a period of 1 week to evaluate accurate WL using techniques and they were blinded to the results of RWL and stereomicroscopic measurements of the canal; this is done to evaluate the intraexaminer's agreement of accuracy of WL. Examiners performed the measurements at three different instances with adequate time intervals between subsequent measurements. It was made sure that the examiners were unaware of the measurement made in previous instances. The "Bradley–Blackwood F statistic" showed that "measurements made by two out of three raters (first and third rater) for "experimental technique" had better concordance with "stereoscopic measurements" in comparison with "conventional technique" for only the third rater. This reaffirms the fact that "experimental method" had better concordance with "stereoscopic measurements" than "conventional method."

Determination of CDJ is successfully achieved by histopathological studies. Estimates that were within 0.5–1 mm short of the stereomicroscopic measurement were considered to be accurate.[14]

The limitation of our study is that only closed apices samples were selected. In the experimental setup, saline acts as an electrolyte instead of saliva.

CONCLUSIONS

The experimental technique showed perfect agreement between examiners in locating the minor constriction of apical foramen than the conventional technique. In addition, further studies are needed to conduct and evaluate the accuracy of WL using experimental techniques in cases of apical resorption.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

REFERENCES

1. Nasiri K, Wrbas KT. Accuracy of different generations of apex locators in determining working length; a systematic review and meta-analysis. Saudi Dent J 2022;34:11-20.
2. American Association of Endodontists. Glossary of Endodontic Terms. 7th ed. Chicago: American Association of Endodontists; 2003.
3. Aeschbacher S, Blum S, Meyre PB, Coslovsky M, Vischer AS, Sinnecker T, *et al*. Blood pressure and brain lesions in patients with atrial fibrillation. Hypertension 2021;77:662-71.
4. Tsesis I, Blazer T, Ben-Izhack G, Taschieri S, Del Fabbro M, Corbella S, *et al*. The precision of electronic apex locators in working length determination: A systematic review and meta-analysis of the literature. J Endod 2015;41:1818-23.
5. Williams CB, Joyce AP, Roberts S. A comparison between *in vivo* radiographic working length determination and measurement after extraction. J Endod 2006;32:624-7.
6. ElAyouti A, Weiger R, Löst C. The ability of root ZX apex locator to reduce the frequency of overestimated radiographic working length. J Endod 2002;28:116-9.

Downloaded from http://journals.lww.com/jcde by BhDMf5ePHKav1zEoum1tQfN4a+kJLhEZgbsIHo4XMi0hCywCX1AWnYQp/IlQrHD3i3D0OdRyi7TvSFl4Cf3VC1y0abggQZXdgGj2MwlZLeI= on 03/12/2024

7. Kim E, Lee SJ. Electronic apex locator. Dent Clin North Am 2004;48:35-54.
8. Hoer D, Attin T. The accuracy of electronic working length determination. Int Endod J 2004;37:125-31.
9. Weiger R, John C, Geigle H, Löst C. An *in vitro* comparison of two modern apex locators. J Endod 1999;25:765-8.
10. Vieyra JP, Acosta J, Mondaca JM. Comparison of working length determination with radiographs and two electronic apex locators. Int Endod J 2010;43:16-20.
11. Czerw RJ, Fulkerson MS, Donnelly JC, Walmann JO. *In vitro* evaluation of the accuracy of several electronic apex locators. J Endod 1995;21:572-5.
12. Nekoofar MH, Ghandi MM, Hayes SJ, Dummer PM. The fundamental operating principles of electronic root canal length measurement devices. Int Endod J 2006;39:595-609.
13. Singh H, Kapoor P. Generations of apex locators: Which generation are we in? Stomatological Dis Sci 2019;3:4.
14. Katz A, Tamse A, Kaufman AY. Tooth length determination: A review. Oral Surg Oral Med Oral Pathol 1991;72:238-42.
15. Hembrough JH, Weine FS, Pisano JV, Eskoz N. Accuracy of an electronic apex locator: A clinical evaluation in maxillary molars. J Endod 1993;19:242-6.
16. Oliveira TN, Vivacqua-Gomes N, Bernardes RA, Vivan RR, Duarte MA, Vasconcelos BC. Determination of the accuracy of 5 electronic apex locators in the function of different employment protocols. J Endod 2017;43:1663-7.
17. Swapna DV, Krishna A, Patil AC, Rashmi K, Pai VS, Ranjini MA. Comparison of third generation versus fourth generation electronic apex locators in detecting apical constriction: An *in vivo* study. J Conserv Dent 2015;18:288-91.
18. Somma F, Castagnola R, Lajolo C, Paternò Holtzman L, Marigo L. *In vivo* accuracy of three electronic root canal length measurement devices: Dentaport ZX, Raypex 5 and ProPex II. Int Endod J 2012;45:552-6.
19. Thomas AS, Hartwell GR, Moon PC. The accuracy of the Root ZX electronic apex locator using stainless-steel and nickel-titanium files.J Endod 2003;29:662-3.
20. Nguyen HQ, Kaufman AY, Komorowski RC, Friedman S. Electronic length measurement using small and large files in enlarged canals. Int Endod J 1996;29:359-64.
21. Sadeghi S, Abolghasemi M. The effect of file size on the accuracy of the raypex 5 apex locator: an in vitro study. J Dent Res Dent Clin Dent Prospects 2008;2:24-7.

Downloaded from http://journals.lww.com/jcde by BhDMf5ePHKav1zEoum1tQfN4a+kJLhEZgbsIHo4XMi0hCywCX1AWnYQp/IlQrHD3i3D0OdRyi7TvSFl4Cf3VC1y0abggQZXdgGj2MwlZLeI= on 03/12/2024