IDR International Dental Research

Original Article

Comparison of the accuracy of different electronic apex locators used in working length determination via changing of initial cleaning solutions

Güliz Rana Tellioğlu Avcı[1], Sadullah Kaya[1]

[1] Dicle University, Faculty of Dentistry, Department of Endoodontics, Diyarbakır, Turkey

Abstract

Aim: The aim of this study is to compare the accuracy of the different new generation electronic apex locators by changing the initial cleaning solutions (NaOCl vs. EDTA).

Methodology: Eighty mandibular premolar teeth were used. Radiographs were obtained from the mesio-distal, and bucco-lingual angles for all teeth, and teeth with suspected external or internal root resorption and/or calcified canals were not included in the study. The true lengths of the root canals were determined with a precision of 0.01 mm with a stereomicroscope at x5 magnification by placing a #20 K-type canal file into the root canal. The samples were then embedded in freshly mixed alginate blocks up to the cemento-enamel junction. The coronal 1/3 was pre-enlarged with a Protaper SX (VDW, Munich, Germany), instrument. Root ZX Mini (J. Morita, Tokyo, Japan), Raypex 6 (VDW, Munich, Germany), Propex Pixi (Dentsply Maillefer, Ballaigues, Switzerland), and E-Pex Pro (Changzhou Sifary Medical Technology Co., Ltd, Jiangsu, China) electronic apex locators were used, and measurements were made by changing the initial solutions (NaOCl vs. EDTA). Distilled water was used between application of 5.25% NaOCl and 17% EDTA to prevent chemical interactions. Three measurements were taken for each tooth, and the average of these three measurements was taken as reference. The data obtained in this study were analyzed.

Results: There were no statistically significant differences between the solutions in terms of the measurement values and actual length values found by each device ($p>0.05$). Although there were no statistically significant differences, the deviation from the actual measurement was greater when EDTA solution was used than when NaOCl solution was used. In addition, although the difference was not found to be statistically significant, the deviation from the actual measurement was found to be highest when the Root ZX mini device was used with NaOCl and EDTA solution.

Conclusion: The results of this study showed that the difference in the initial washing solutions did not affect the electronic apex locator (EAL) devices in making measurements close to the true length.

Keywords: working length, electronic apex locator, initial solutions

How to cite this article: Tellioğlu Avcı GR, Kaya S. Comparison of the accuracy of different electronic apex locators used in working length determination via changing of initial cleaning solutions. Int Dent Res 2021;11(Suppl.1):56-62. https://doi.org/10.5577/intdentres.2021.vol11.suppl1.9

Correspondence:

Dr. Güliz Rana TELLİOĞLU AVCI
Dicle University, Faculty of Dentistry, Department of Endodontics, Diyarbakır, Turkey
E-mail: grtellioglu@hotmail.com

Received: 6 February 2021
Accepted: 11 May 2021

Access Online

DOI:
10.5577/intdentres.2021.vol11.suppl1.9

Introduction

Determining the working length correctly while performing root canal treatment is an important step in ensuring the success of the treatment (1). If the working length is not determined correctly, disinfection and preparation processes are insufficient.

If the working length is determined to be shorter than the root canal length, uncleaned areas remain, and in case of long work, irritation of the periapical area occurs. Root canal treatment may fail in both cases (2).

Determination of the working length is made with different methods. Finger sensitivity, electronic apex finder, radiographic method, and moisture in paper cones are among these methods. In the radiographic method, the radiological apex point is taken as a reference, and the minor and major foramen points are estimated according to this point. The radiographic method has several disadvantages. One of the most important disadvantages is that reference points are not always localized. Reasons for this include superpositions, anatomical variations, overlapping of images in the buccolingual direction, obtaining two-dimensional images from radiographs, and image distortions (3, 4). To eliminate these disadvantages of the radiographic method, electronic apex locators (EAL) have come to the fore. With electronic apex locators (EAL), measurements can be made easily, quickly, and precisely, and the physician and patient are protected from radiation.

At the same time, the difficulty of filming in pediatric patients, difficulties in placing films, and the problems encountered in pregnant patients and those with vomiting reflexes are eliminated with the use of EAL.

Materials and Methods

This in vitro study was approved scientifically and ethically by the Dicle University, Faculty of Dentistry Ethics Committee (protocol number 2019/33, dated 19.07.2019. This in vitro study was found scientifically and ethically appropriate by the Dicle University, Faculty of Dentistry Ethics Committee (protocol number 2019/33, dated 19.07.2019).

In the study, 80 mandibular premolar teeth were used, each with a single root and a single canal and closed apex, without caries and restoration, and extracted for prosthetic and periodontal reasons. Radiographs were taken from mesio-distal and bucco-lingual angles for all teeth, and teeth with external or internal root resorption and calcified canals were not included in the study. Soft tissue residues and debris were removed from the teeth using a periodontal crest and curette. The teeth were stored in distilled water at room temperature until they were used in the study.

The buccal tubercle of the teeth was straightened to obtain a stable reference line. After opening the standard entrance cavity, the canal openings were determined, and pulp residues and debris were removed. The coronal 1/3 of each tooth was enlarged with a Protaper SX (Dentsply Sirona, NY, USA) file. A #20 type-K (VDW GmbH, Munich, Germany) canal instrument was placed on the teeth, and this instrument was advanced under a stereomicroscope (Leica, Wetzlar, Germany) at x5 magnification until it was visible through the major foramen. The rubber stopper of the file was fully inserted into the flattened buccal tubercle. Then in the removed channel distance between the handpiece and the stopper end portion of the lower edge of 0.01 mm precision with digital calipers (AEK-Tech, Istanbul, Turkey) were measured using.

The measurement obtained for each tooth was recorded as the total length of the root canal, 0.5 mm was subtracted from this recorded value, and the resulting value was taken as the actual root canal working length. Tooth roots were embedded in the alginate (Dentsply Sirona, NY, USA) model up to the enamel-cementum border to mimic the periodontal ligament in vitro. The lip clip of the electronic apex finder used in the study was embedded in the alginate model. Type K file # 20 was placed inside the tooth. The holder end of the device was applied to the file and electronic measurements were started. Root canals were washed with distilled water and dried with paper cones after each solution use in order to prevent contact of irrigation solutions used.

The devices were used in accordance with the manufacturer's recommendations, and electronic measurements of the samples were made and recorded. While root canal before the EAL measurement device 1 ml 5,25'lik% NaOCl (Promida, Eskisehir, Turkey) were irrigated with a solution, measurements were made. NaviTip (Ultradent, South Jordan, USA) irrigation needle was used for irrigation. The canal was then washed with 5 ml of distilled water and dried. This time, the root canal was irrigated with 1 ml of 17% EDTA (Prime Dental Products Pvt. Ltd. Thane, India) solution and re-measurements were made.

Statistical analysis

Analysis of the data was carried out with SPSS software version 22 (IBM SPSS Inc., Armonk, NY, USA). The normality of the distribution was checked with the Kolmogorov-Smirnov test. While examining the differences between the groups, Mann-Whitney U and Kruskal Wallis-H tests were used if the variables did not come from a normal distribution. In case of significant difference, significant groups were determined by using post-hoc tests ($p>0.05$).

Results

In this study, 80 observations for each solution and 160 observations for each device were made using 4 devices and 2 solutions. Table 1 shows the data obtained between solutions in terms of measurement values and actual length values in each device. There is no statistically significant difference ($p> 0.05$). Table 2 shows the data obtained between the devices in terms of measurement values and actual length values in each solution. There is no statistically significant difference ($p> 0.05$).

Table 1. Difference between solutions in terms of measurements on instruments and actual length values

	s		Solution						Mann Whitney U Test	
			n	Mean	Median	Min	Max	SS	Mean Rank	z	p
Morita Root ZX mini	Measurements	NaOCl	80	20,35	20,4	15,6	24,4	1,83	80,99		
		EDTA	80	20,32	20,35	15,4	24,7	1,83	80,01	-0,135	0,893
		Total	160	20,34	20,4	15,4	24,7	1,82			
	Actual length	NaOCl	80	20,79	20,7	16,5	25	1,68	80,5		
		EDTA	80	20,79	20,7	16,5	25	1,68	80,5	0	1
		Total	160	20,79	20,7	16,5	25	1,67			
Raypex 6	Measurements	NaOCl	80	20,39	20,5	16	24,4	1,73	80,56		
		EDTA	80	20,4	20,35	15,8	24,7	1,73	80,44	-0,015	0,988
		Total	160	20,39	20,5	15,8	24,7	1,72			
	Actual length	NaOCl	80	20,79	20,7	16,5	25	1,68	80,5		
		EDTA	80	20,79	20,7	16,5	25	1,68	80,5	0	1
		Total	160	20,79	20,7	16,5	25	1,67			
Propex Pixi	Measurements	NaOCl	80	20,47	20,5	15,9	24,5	1,73	80,46		
		EDTA	80	20,46	20,5	15,5	24,4	1,75	80,54	-0,012	0,99
		Total	160	20,46	20,5	15,5	24,5	1,73			
	Actual length	NaOCl	80	20,79	20,7	16,5	25	1,68	80,5		
		EDTA	80	20,79	20,7	16,5	25	1,68	80,5	0	1
		Total	160	20,79	20,7	16,5	25	1,67			
E-pex	Measurements	NaOCl	80	20,48	20,7	15,2	24,5	1,81	81,73		
		EDTA	80	20,43	20,5	16,4	24,4	1,76	79,27	-0,336	0,737
		Total	160	20,45	20,6	15,2	24,5	1,78			
	Actual length	NaOCl	80	20,79	20,7	16,5	25	1,68	80,5		
		EDTA	80	20,79	20,7	16,5	25	1,68	80,5	0	1
		Total	160	20,79	20,7	16,5	25	1,67			

Table 2. Difference between devices in terms of deviations from the actual measurement in solutions

		Device						*Kruskal Wallis H Testi*		
			n	Mean	Median	Min	Max	ss	Mean Rank	H	p
NaOCl	Measurements	Morita Root ZX mini	80	20,35	20,4	15,6	24,4	1,83	156,24	0,425	0,935
		Raypex 6	80	20,39	20,5	16	24,4	1,73	158,58		
		Propex Pixi	80	20,47	20,5	15,9	24,5	1,73	162,09		
		E-pex	80	20,48	20,7	15,2	24,5	1,81	165,09		

EDTA		Total	320	20,42	20,55	15,2	24,5	1,77			
	Actual length	Morita Root ZX mini	80	20,79	20,7	16,5	25	1,68	160,5	0	1
		Raypex 6	80	20,79	20,7	16,5	25	1,68	160,5		
		Propex Pixi	80	20,79	20,7	16,5	25	1,68	160,5		
		E-pex	80	20,79	20,7	16,5	25	1,68	160,5		
		Total	320	20,79	20,7	16,5	25	1,67			
	Measurements	Morita Root ZX mini	80	20,32	20,35	15,4	24,7	1,83	156,45	0,255	0,968
		Raypex 6	80	20,4	20,35	15,8	24,7	1,73	160,34		
		Propex Pixi	80	20,46	20,5	15,5	24,4	1,75	163,59		
		E-pex	80	20,43	20,5	16,4	24,4	1,76	161,61		
		Total	320	20,4	20,45	15,4	24,7	1,76			
	Actual length	Morita Root ZX mini	80	20,79	20,7	16,5	25	1,68	160,5	0	1
		Raypex 6	80	20,79	20,7	16,5	25	1,68	160,5		
		Propex Pixi	80	20,79	20,7	16,5	25	1,68	160,5		
		E-pex	80	20,79	20,7	16,5	25	1,68	160,5		
		Total	320	20,79	20,7	16,5	25	1,67			

There is a statistically significant relationship between the actual length and the measurements in each group ($p < 0.05$). Table 3 shows there is a positive and strong correlation between the actual length and the measurements in each group. Figure 1 shows the differences between the devices in terms of deviations from the actual measurement in solutions.

Table 3. Relationship between actual length and measured values

		Actual length	Morita Root ZX Mini NaOCl	Morita Root ZX Mini EDTA	Raypex 6 NaOCl	Raypex 6 EDTA	Propex Pixi NaOCl	Propex Pixi EDTA	E-Pex NaOCl
Morita Root ZX Mini NaOCl	r	,965**							

Morita Root ZX Mini EDTA	r	,981**	,972**						
Raypex 6 NaOCl	r	,966**	,982**	,967**					
Raypex 6 EDTA	r	,972**	,971**	,982**	,965**				
Propex Pixi NaOCl	r	,966**	,980**	,984**	,973**	,972**			
Propex Pixi EDTA	r	,969**	,973**	,982**	,966**	,981**	,977**		
E-Pex NaOCl	r	,952**	,960**	,963**	,961**	,960**	,965**	,959**	
E-Pex EDTA	r	,970**	,968**	,983**	,963**	,978**	,974**	,976**	,948**

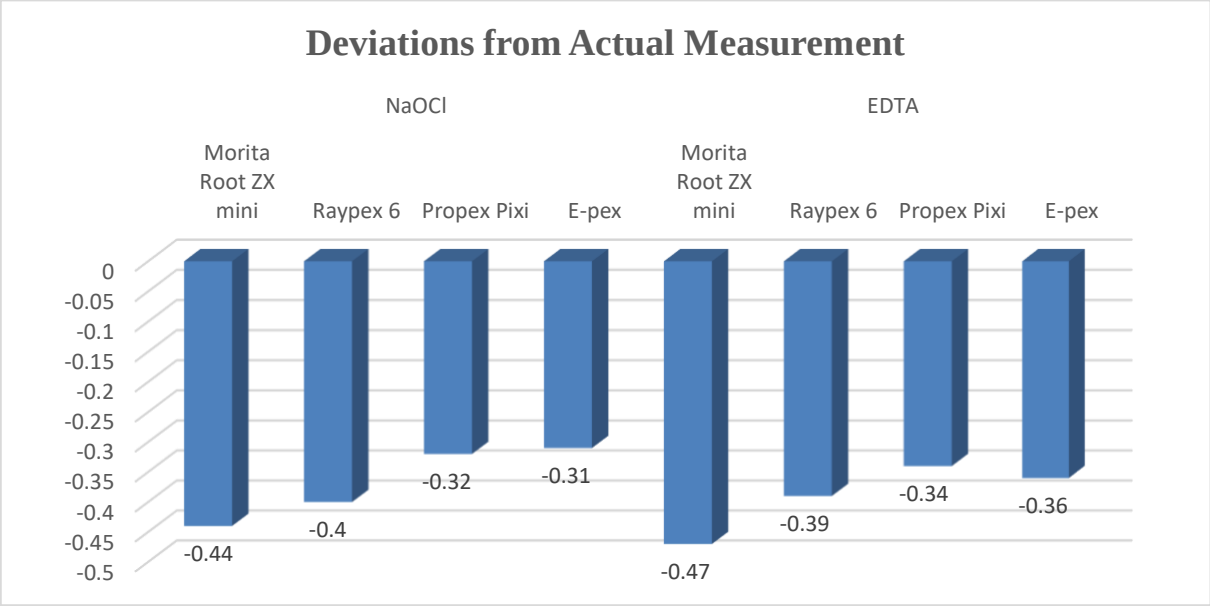

Figure 1. Difference between solutions in terms of deviations from actual measurement on instruments

There is no statistically significant difference between the devices in terms of deviation from the actual measurement in NaOCl solution ($p > 0.05$). Although not statistically significant, NaOCl solution decreased more in Morita Root ZX mini device than all other devices in terms of deviation from the actual measurement. There is no statistically significant difference between the devices in terms of deviation from the actual measurement in EDTA solution ($p > 0.05$). Although not statistically significant, EDTA solution decreased more in Morita Root ZX mini device than all other devices in terms of deviation from the actual measurement.

Discussion

An adequate shaping in root canal treatment can be achieved by accurately determining the working length of the canal. The canal's working length is defined as the distance between a fixed reference

point determined in the coronal region of the relevant tooth and the point where the shaping and filling will be completed. If the working length cannot be determined exactly, insufficient or overflow shaping is made in the root canal. When the flood shaping is done, the apical narrowing area is disrupted, and the periapical tissues are damaged. In insufficient shaping, microorganisms cannot be completely cleaned, and the success rate of endodontic treatment decreases (5).

The working length is usually determined by radiographs; however, radiographic evaluations may not give complete results depending on the relationship between the anatomic apex and the major foramen and the canal curvature. In addition, since radiographs provide two-dimensional images, they may cause misinterpretation. For all these reasons, it is recommended to use EALs together with radiographs in order to accurately determine the working length (6).

Wu et al. stated in the studies that the teeth used to minimize the differences should be the same group. The canal diameters, canal anatomy, and dimensions of these teeth should be similar to each other. He also stated that teeth without decay and restoration should be used in order to achieve standardization (7). For all these reasons, in our study, to avoid anatomical differences and standardize root canals, single-rooted, and single canal, caries-free, non-restorative, newly extracted lower premolar teeth were used. Before starting the study, radiographs were taken from the mesiodistal and buccolingual directions to determine that the teeth had a single canal.

It has been reported that the rubber stopper on the file should be fixed on a flat surface in order to reduce the errors that may occur in studies conducted with EAL's and not to affect the results of the study (8, 9). For this reason, in this study, the buccal tubercle tops of the teeth were flattened with diamond burs under water cooling, and a fixed reference point was obtained.

Lucena-Martin et al., in their study, reported that electronic measurements should be completed within 2 hours after mixing the alginate in order to minimize moisture loss (10).

Lipski et al. argued that electronically the most accurate measurements were obtained within 30 minutes after mixing the alginate (11). In this study, while electronic measurements were made, alginate was mixed every 30 minutes again.

In the light of studies stating that the point where the endodontic treatment should be terminated should be the minor foramen (12, 13), in this study, the minor foramen was determined as the apical border where the treatment should be completed and based on the knowledge that the minor foramen was 0.5-1 mm behind the major foramen, it was determined in the crown of the tooth. The length obtained by subtracting 0.5 mm from the measured distance between the reference point and the major foramen was accepted as the true canal length.

Trope et al. reported that in the presence of electroconductors such as moisture, irrigation solution, and vital pulp tissue in the canal, the measurement accuracy of older generation EAL devices decreased (14). Kobayashi et al. reported that impedance ratios at different frequencies do not change in the presence of different electroconductors (such as distilled water, EDTA, NaOCl) in the root canal (15). Altunbaş et al., in their study, used 0.9% NaCl, 17% EDTA and 2.5% NaOCl solutions as irrigation solutions and evaluated the measurement accuracy of two different EAL's in the presence of these irrigation solutions and in a dry environment. In the measurements made with the Dentaport ZX device, the closest results to the actual working length were obtained in the presence of 17% EDTA in the canal, and the most distant results were in the presence of 2.5% NaOCl in the canal. In the rooter device, the closest results were obtained when the canal was dry, while the most distant results were obtained in the presence of 0.9% NaOCl in the root canal (16).

Venturi and Breschi, in their study with Root ZX and Apexfinder devices, reported that the measurements made were inaccurate and unbalanced when the root canals were dry (in low conductive conditions) (17). Fan et al. used Root ZX, Propex, and Neosono Ultima EZ devices in their study. They examined the accuracy of these devices in the presence of different irrigation solutions in the canal. They found that EALs' accuracy when electroconductive liquid is present in the root canal decreases (18). Marigo et al. reported that the accuracy of the Dentaport ZX device did not change in the presence or absence of NaOCl in the root canal (19). Duran-Sindreu et al., in a study by Root ZX and iPex, the accuracies of the devices were evaluated in the presence of different irrigation solutions (NaOCl and chlorhexidine) in the canal. According to the results of the study, it was reported that the use of other irrigation solutions did not affect the accuracy of EAL devices (20).

Evcil et al. compared the Apex Pointer and Propex devices in vitro by changing the washing solutions (saline, EDTA, NaOCl) in incisor and premolar teeth. They found no significant difference between the groups (21). Jenkins et al. in a study conducted, looked at the accuracy of the Root ZX device in the presence of different irrigation solutions (RC Prep, Peridex, EDTA, 5.25% NaOCl, 3% H2O2) and found that these solutions did not have any effect on the accuracy of the device (22).

Serna-Pena et al., in an in vivo study they performed, the accuracy of three different EAL devices (Root ZX Mini, Propex Pixi, and Apex ID) were evaluated on teeth with extraction indications, and no statistically significant difference was found (23).

Gehlot et al. examined the accuracy of four different EAL devices (Root ZX, Propex Pixi, Elements diagnostic unit and apex locator, SybronEndo Mini Apex Locator) and whether the structure (stainless steel and nickel-titanium) of the file being measured changed. As a result of the study, a statistically significant difference was found in the measurement accuracy of Root ZX. While the measurement accuracy of Root ZX was 93.3% in the stainless-steel file, it was found as 70% in the Ni-Ti file (24).

Conclusions

According to the results of our current study, no statistically significant difference was found between the solutions in terms of measurement values and actual length values in each device ($p > 0.05$). In addition, there was no statistically significant difference between the devices in terms of measurement values and actual length values in each solution ($p > 0.05$). The results of this study showed that the difference in the initial washing solutions did not affect the EAL devices in making measurements close to the true length.

Acknowledgments: This study was presented as a full-text oral presentation at the 1st International Dental Research and Health Sciences Congress held between 20-22 May 2021.

Ethical Approval: Ethics committee approval was received for this study from Human Ethics Research Committee at Dicle University Faculty of Dentistry Ethics Committee (protocol number 2019/33, dated 19.07.2019).

Peer-review: Externally peer-reviewed.

Author Contributions: Conception – G.R.T.A.; Design –S.K.; Supervision – S.K.; Materials – G.R.T.A.; Data Collection and/or Processing – G.R.T.A.; Analysis and/or Interpretation – G.R.T.A.; Literature Review – S.K.; Writer – G.R.T.A.; Critical Review – S.K.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: This study has been supported by the Scientific Research Projects Coordination Unit of Dicle University, Turkey. (Project No: DİŞ.19.013).

References

1. Schilder H. Filling root canals in three dimensions. Journal of Endodontics, 2006; 32(4): p. 281-290. (Crossref)
2. Chugal NM, Clive JM, and Spångberg LS. Endodontic infection: some biologic and treatment factors associated with outcome. Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology, 2003; 96(1): p. 81-90. (Crossref)
3. Krishnan IS, and Sreedharan S. A comparative evaluation of electronic and radiographic determination of root canal length in primary teeth: An in vitro study. Contemporary Clinical Dentistry, 2012; 3(4): p. 416. (Crossref)
4. Stein TJ, and Corcoran JF. Radiographic "working length" revisited. Oral surgery, Oral Medicine, Oral Pathology, 1992; 74(6): p. 796-800. (Crossref)
5. Moscoso S. Evaluation of Dentaport ZX and Raypex 6 electronic apex locators: an in vivo study. Medicina Oral, Patologia Oral y Cirugia Bucal, 2014; 19(2): p. e202. (Crossref)
6. ElAyouti A, Weiger R, and Löst C. The ability of root ZX apex locator to reduce the frequency of overestimated radiographic working length. Journal of Endodontics, 2002; 28(2): p. 116-119. (Crossref)
7. Retief D. Standardizing laboratory adhesion tests. American Journal of Dentistry, 1991; 4(5): p. 231-236.
8. Jakobson SJM. The accuracy in the control of the apical extent of rotary canal instrumentation using Root ZX II and ProTaper instruments: an in vivo study. Journal of Endodontics, 2008; 34(11): p. 1342-1345. (Crossref)
9. D'assunção F. Ex vivo evaluation of the accuracy and coefficient of repeatability of three electronic apex locators using a simple mounting model: a preliminary report. International Endodontic Journal, 2010; 43(4): p. 269-274. (Crossref)
10. Lucena-Martin C. In vitro evaluation of the accuracy of three electronic apex locators. Journal of Endodontics, 2004; 30(4): p. 231-233. (Crossref)
11. Lipski M. Evaluation of alginate as a substitute for root-surrounding tissues in electronic root canal measurements. Australian Endodontic Journal, 2013; 39(3): p. 155-158. (Crossref)
12. Grove CJ. Why root canals should be filled to the dentinocemental junction. The Journal of the American Dental Association (1922), 1930; 17(2): p. 293-296. (Crossref)
13. Ricucci D, and Langeland K. Apical limit of root canal instrumentation and obturation, part 2. A histological study. International Endodontic Journal, 1998; 31(6):p.394. (Crossref)
14. Trope M, Rabie G, and Tronstad L. Accuracy of an electronic apex locator under controlled clinical conditions. Dental Traumatology, 1985; 1(4): p. 142-145. (Crossref)
15. Kobayashi C. New practical model of the division method electronic root canal length measuring device. J Jpn Endodon Assoc, 1991; 12: p. 143-148.
16. Altunbaş D, Kuştarcı A, and Toyoğlu M. The influence of various irrigants on the accuracy of 2 electronic apex locators in locating simulated root perforations. Journal of Endodontics, 2017; 43(3): p. 439-442. (Crossref)
17. Venturi M, and Breschi L. A comparison between two electronic apex locators: an in vivo investigation. International Endodontic Journal, 2005; 38(1): p. 36-45. (Crossref)
18. Fan W. Evaluation of the accuracy of three electronic apex locators using glass tubules. International Endodontic Journal, 2006; 39(2): p. 127-135. (Crossref)
19. Marigo L. Comparison of two electronic apex locators on human cadavers. Clinical Oral Investigations, 2016; 20(7): p. 1547-1550. (Crossref)
20. Duran-Sindreu F. In vivo evaluation of the iPex and Root ZX electronic apex locators using various irrigants. International Endodontic Journal, 2013; 46(8): p. 769-774. (Crossref)
21. Evcil MS. Comparison of Accuracy of Two Different Apex Finders Using Different Canal Washing Solutions. Journal of Atatürk University Faculty of Dentistry, 2012; (2): p. 132-137.
22. Jenkins JA. An in vitro evaluation of the accuracy of the root ZX in the presence of various irrigants. Journal of Endodontics, 2001; 27(3): p. 209-211. (Crossref)
23. Serna-Peña G. In vivo evaluation of 3 electronic apex locators: Root ZX Mini, Apex ID, and Propex Pixi. Journal of Endodontics, 2020; 46(2): p. 158-161. (Crossref)
24. Gehlot PM, Manjunath V, and Manjunath MK. An in vitro evaluation of the accuracy of four electronic apex locators using stainless-steel and nickel-titanium hand files. Restorative Dentistry & Endodontics, 2016; 41(1): p. 6-11. (Crossref)