



Effect of Various Electronic Devices on the Performance of Electronic Apex Locator

Masoud Parirokh^a, Hamed Manocherifar^{b*}, Paul V. Abbott^c, Roya Borna^d, Ali Akbar Haghdoost^e

^a Social Determinants on Oral Health Research Center, Kerman University of Medical Sciences, Kerman, Iran; ^b Endodontology Research Center, Kerman University of Medical Sciences, Kerman, Iran; ^c School of Dentistry, University of Western Australia, Perth, Australia; ^d Oral and Dental Diseases Research Center, School of Dentistry, Kerman Medical Science University, Kerman, Iran; ^e Research Center for Modeling in Health, Kerman University of Medical Sciences, Kerman, Iran

ARTICLE INFO

Article Type: Original Article

Received: 03 Apr 2019

Revised: 19 Jul 2019

Accepted: 04 Aug 2019

Doi: 10.22037/iej.v14i4.23752

*Corresponding author: Hamed Manocherifar, Endodontology Research Center, Kerman University of Medical Sciences, Kerman, Iran.

E-mail: h.manochehrifar@kmu.ac.ir

Tel: +98-914 3154323

© The Author(s). 2018 Open Access This work is licensed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International.

ABSTRACT

Introduction: Apex locators are important devices that can be used to determine working length during root canal treatment. However, it is not known whether electronic devices with various wave length frequencies influence the accuracy of apex locators. The aim of this study was to determine whether a cordless phone set, MP4 player, FM radio, asymmetric digital subscriber line (ADSL), or a mobile phone could influence the accuracy of working length determination by the Dentaport ZX apex locator. **Methods and Materials:** In this study, twenty-four sound intact single-rooted extracted human teeth were used. After determining the root canal length with a file and a microscope, the canals were measured with three separate Dentaport ZX apex locators while one of the test devices (ADSL, MP4, FM radio, mobile phone, and cordless phone) was used at a distance of 50 cm from the apex locator. Bland-Altman plots was used for reliability and consistency. **Results:** Except for the FM radio, all other devices showed significant difference with actual working length ($P < 0.05$). ADSL and MP4 player showed the least consistency compared to the other devices. **Conclusion:** Based on this *in vitro* study, the use of ADSL, MP4 player, mobile phone, and cordless phone during root canal treatment may influence working length determination with the Dentaport ZX apex locator.

Keywords: ADSL; Apex Locator; Cell Phone; Dentaport ZX Apex Locator; MP4 Player; Radio; Wave Length

Introduction

The aim of root canal treatment is to eradicate all possible bacteria, irritants and necrotic tissue from the root canal space [1]. To achieve this, it is crucial to determine the root canal length and keep the instruments, irrigants and medicaments confined to within the root canal space during the procedure [1, 2] since even when the instruments confined within the canal all techniques and irrigants can result in some extrusion beyond the apical foramen [3-5]. Numerous investigations have shown that errors in determining the working length may influence not only outcome of the root canal treatment but also they may have an impact on the

amount of pain and discomfort following the procedure [6-8].

Several methods have been described for working length determination and these include tactile sense, radiographic measurement, employing cone-beam computed tomography and using electronic apex locators (EAL) [9-13]. Investigations of EAL have shown that they are reliable devices that can be a reasonable adjunct to radiographic techniques to simplify working length determination. It is generally accepted that using EAL can help clinicians decrease the number of radiographs taken during root canal treatment [9].

The Dentaport Root ZX (J. Morita Corporation, Kyoto, Japan) apex locator belongs to the third generation of apex locators and has been shown to be reliable [2].

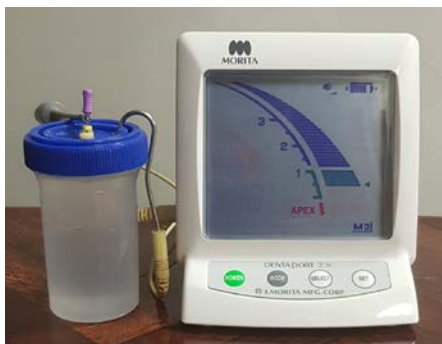


Figure 1. Working length measurement with EALS

Nowadays, there are many devices that use radio frequency with different wave lengths and these are commonly used in most urban environments from offices to homes. Most investigations regarding impact of electronic devices on the accuracy of working length measurements of electronic apex locators used cell phones or cordless phones for this purpose [14-16]. The aim of the present investigation was to determine the effect of asymmetric digital subscriber line (ADSL), MP4 player, cordless telephone, mobile phone and frequency modulation (FM) radio wave on an apex locator.

Materials and Methods

In this study, 24 single-rooted freshly extracted human teeth were collected from dental clinics of the Kerman city. The teeth were initially examined under a dental operative microscope (Carl Zeiss Surgical GmbH, Oberkochen, Germany) and any teeth with apical resorption, root tip fracture, a curved root, had previous endodontic treatment or an open apical foramina were excluded.

The teeth were decoronated at the cemento-enamel junction level in order to have a standard access and stable reference point for working length determination. The actual working length (AWL) of each root was determined by inserting a size 10 K-file (Mani, Tochigi, Japan) into the root canal and observing it under the microscope under 25× magnification to determine when the file tip reached the apical foramen. The rubber stopper was then positioned at the level of the reference point. The working length was then set at 0.5 mm less than the length observed.

Each root was fixed into a plastic bottle and the Dentaport ZX lip clip was also fixed in the bottle so that a complete circuit was provided. Each bottle was filled with 0.9% normal saline as a conducting medium. Before starting the measurements, the cervical part of the root canals was enlarged with Gates Glidden sizes 2 and 3 (Mani, Tochigi, Japan) (Figure 1).

All initial measurements with the Dentaport ZX apex locators were performed in a room after making sure that there

were no known devices with radio waves (such as wireless systems, cordless phones, mobile phones, MP4 player, TV remote control) present. Each root canal was filled with 2.5% sodium hypochlorite and a size 10 K-file was inserted into the root canal to determine the working length with the Dentaport ZX apex locator. The root canal length was then determined by an experienced operator with three new Dentaport ZX devices (serial numbers: ZJ3290, ZI3073, ZJ 3288) when one of the following devices was on: MP4 player (Creative, Mozaic, EZ 300, Shenzhen, China), FM radio (Stereo-Radio cassette carrying component system, FM 87.5 MHz, Aiwa-CA-WR77, Tokyo, Japan), ADSL (D-Link, Wireless N 150 ADSL2+Modem router, DSL-2730u-2.4 GHz, China, 1C7EE54F1945), or ringing: mobile phone (Nokia, C5-03, Hungary), a cordless telephone (KX-TG3721BX, Panasonic System Network Co. LTD, Malaysia) at a distance of 50 cm from the electronic apex locators. The Dentaport ZX was used in accordance with the manufacturer's instructions and the electrode was connected to a size 15 K-type file. The instrument was inserted into the root canal and advanced just beyond the major foramen as indicated by the flashing APEX bar on the monitor of the Dentaport ZX. The instrument was then slowly withdrawn until the monitor showed a flashing bar between "APEX" and 1 to indicate a 0.5 reading. All measurements were assumed correct if the instrument remained stable for at least 5 sec[17].

In order to measure the effect of nuisance devices on apex devices measurement the Bland-Altman method with repeated measure was used. At first, the difference between microscope and apex devices measurement (error) for each tooth was calculated to remove the effect of different apex devices and teeth by applying random effect models. Finally, mean of error, *P*-values for null hypothesis and the Bland-Altman plots was presented. In all analyses, *P*<0.05 was considered as significant.

Results

Almost all of measurements with the apex locators were less than the AWL. The minimum and maximum differences were observed during exposure with a ringing telephone (0.52 mm) and a working MP4 player (0.83 mm).

The mean of error is significantly different from zero in presence of mobile, ADSL, cordless telephone, and MP4 player device noises (Table 1). Also the Bland-Altman plots shows that the errors are slightly tends to be on top of zero line (Figure 2).

Except for FM radio, all of other electronic devices tested showed significantly higher errors and disperse results at ±0.00 mm distance from AWL (Table 1).

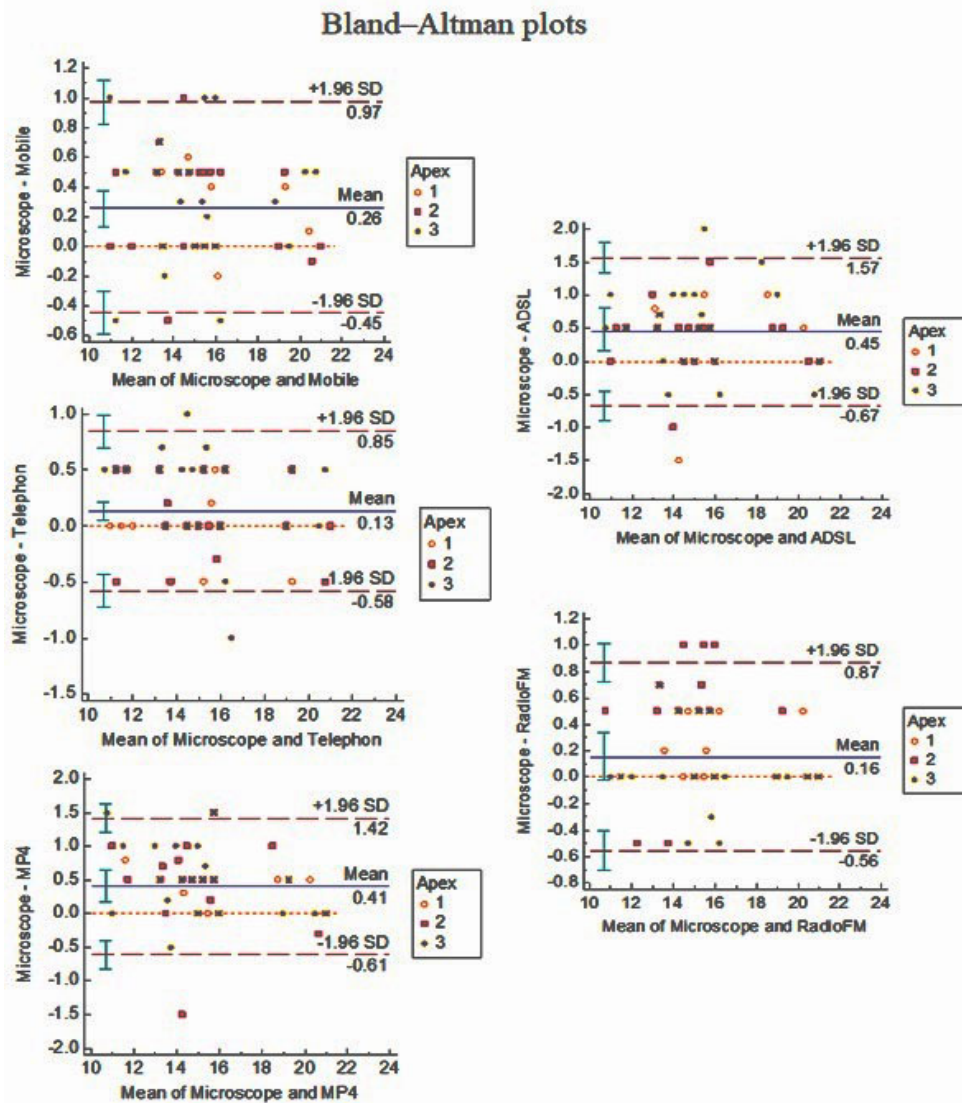


Figure 2. Bland–Altman plots of various electronic devices and differences in working length to the gold standard (microscope)

Discussion

The present study has shown that except for FM radio, all other electronic devices had significant influence on determining the working length of root canals with the Dentaport ZX apex locator.

Previous investigations on working length determination using electronic apex locators indicate that an error range of more than ± 0.5 mm distance from the AWL is clinically unacceptable [18-20]. However, recent investigations simply compared AWL with working length measured by the apex locator [28]). Based on these previous investigations, the results of working length determination with the Dentaport ZX when mobile phone, cordless phone, ADSL and MP4 player devices were used within

50 cm of the measuring device were unacceptable.

In the present study, the Dentaport ZX was used because previous investigations have shown that this device is very accurate in determining working length and many studies have compared new apex locators with this device [21-24].

Three unused brand new Dentaport ZX apex locators were used in this study because the manufacturer has claimed that the working life of the device is six years following production (Root ZX manual). In addition, three different apex locators of the same brand and manufacturer were used as one may argue that using one apex locator may not be conclusive in terms of influence on determining working length determination in presence of the devices with interrupting potential. The results of this study have

shown that, except for FM radio, all of the other electronic devices provided significantly different results in AWL determination with Dentaport ZX during their activity in 50 cm distance from the measuring devices. Different apex locators from the same brand are supposed to show the same working length measurement without significant difference during root canal preparation. However, in the present study, obtaining significantly different results among three used apex locators showed that the FM radio may have some influence on apex locators even when the same brand of device produced by the same manufacturer were used.

AWL was established as 0.5 mm less than the distance between the coronal reference point and the apical opening as observed under a microscope according to several previous investigations [21, 22, 25].

Electronic devices that are likely to be used in many dental offices around the world were tested. Wireless systems, such as ADSL, are now commonly used in dental offices as well as houses, shops and so on. Three previous investigations reported neither types of cell phones could significantly influence on the accuracy of measurement by the EALs [14, 16]. The reason the cell phone was included again in this study was the difference between the frequency ranges of those cell phones [14, 16] with the one that was used in the present study. No significant impact found in those studies [14, 16] was in contrast with the results of the present study may show that different frequency ranges could have some impact on the accuracy of EALs.

The cordless and mobile phones were tested when ringing rather than in actual use because it would be unethical to answer a phone call when a practitioner is treating a patient but he/she might set the mobile phone in silent tone or vibrate mode in his/her pocket. Similarly, the patient or other staff members may have a phone switched on whilst the treatment is in progress.

Overall, the working lengths in the presence of a working FM radio were comparable with previous reports regarding the accuracy of Dentaport ZX [2, 19].

In the present study, none of the measurements were over-estimated which was in accordance with two previously published *ex vivo* studies that showed no over-estimation during working length determination [18, 26].

Previous *ex vivo* investigations of apex locators have used either alginate or normal saline as the conducting medium. A recent investigation compared both media and reported that when the Dentaport ZX was used, there was no significant difference between the media in determining working length [27]. Hence, in the present study 0.09% normal saline was used as the medium as it is simpler and cheaper.

The cervical part of the root canals was enlarged with Gates Glidden drills before using the Dentaport ZX because Ibarrola *et*

al. [28] reported that pre-flaring the canal before using the Root ZX improved the efficacy of the apex locator.

The manufacturer of the Dentaport ZX have declared in their catalog that “*the Dentaport ZX is intended for use in an electromagnetic environment in which radiated radio frequency disturbances are controlled*”. The manufacturer also recommends that a minimum distance from the transmitters should be maintained, based on their maximum output power [29]. A distance of 50 cm from the measuring device was chosen because, in theory, radio waves may interfere with the device’s performance in determining working length when devices with various wave lengths are placed near an apex locator. The results of the present study have shown that for ADSL, mobile phone, cordless phone and MP4 player, careful attention should be made to prevent their presence near the Dentaport ZX during root canal measurement. Another study should be done to determine the safe distance for each device as most dental offices, practitioners or patients have wireless devices switched on during daily activities. In addition, it is necessary to evaluate other forms of apex locators and compare them with the Dentaport ZX in order to understand whether they are also influenced by electronic devices.

Conclusion

In conclusion, based on the results of this study, electronic devices such as ADSL, MP4 player, mobile phone, and cordless phone may have some influence on working length determination with the Dentaport ZX.

Acknowledgment

This study was supported by The Research Committee of Kerman University of Medical Sciences

Conflict of Interest: ‘None declared’.

References

1. Ingle JI, Bakland LK, Baumgartner JC. *Ingle's Endodontics 6*: BC Decker; 2008.
2. Nekoofar M, Ghandi M, Hayes S, Dummer PJJej. The fundamental operating principles of electronic root canal length measurement devices. 2006;39(8):595-609.
3. Mitchell RP, Yang S-E, Baumgartner JCJJoE. Comparison of apical extrusion of NaOCl using the EndoVac or needle irrigation of root canals. 2010;36(2):338-41.
4. Zarrabi MH, Bidar M, Jafarzadeh HJJoos. An in vitro comparative study of apically extruded debris resulting from conventional and three rotary (Profile, Race, FlexMaster) instrumentation techniques. 2006;48(2):85-8.

5. Parirokh M, Jalali S, Haghdoost AA, Abbott PVJJoe. Comparison of the effect of various irrigants on apically extruded debris after root canal preparation. 2012;38(2):196-9.
6. Holland R, Sant'anna Júnior A, Souza Vd, Dezan Junior E, Otoboni Filho JA, Bernabé PFE, Nery MJ, Murata SSJBdj. Influence of apical patency and filling material on healing process of dogs' teeth with vital pulp after root canal therapy. 2005;16(1):9-16.
7. Siqueira Jr J, Barnett FJ. Interappointment pain: mechanisms, diagnosis, and treatment. 2004;7(1):93-109.
8. Gesi A, Hakeberg M, Warfvinge J, Bergenholtz GJOS, Oral Medicine, Oral Pathology, Oral Radiology,, Endodontology. Incidence of periapical lesions and clinical symptoms after pulpectomy-a clinical and radiographic evaluation of 1-versus 2-session treatment. 2006;101(3):379-88.
9. Jarad F, Albadri S, Gamble C, Burnside G, Fox K, Ashley J, Peers G, Preston AJBdj. Working length determination in general dental practice: a randomised controlled trial. 2011;211(12):595.
10. Jeger FB, Janner SF, Bornstein MM, Lussi AJJoe. Endodontic working length measurement with preexisting cone-beam computed tomography scanning: a prospective, controlled clinical study. 2012;38(7):884-8.
11. Janner SF, Jeger FB, Lussi A, Bornstein MMJJoe. Precision of endodontic working length measurements: a pilot investigation comparing cone-beam computed tomography scanning with standard measurement techniques. 2011;37(8):1046-51.
12. Ingle JI, Baumgartner JC. Ingle's endodontics. PMPH-USA; 2008.
13. Sameye MR, Bahalkeh AM, Izadi A, Jafaryan AJIej. Comparison of Digital Radiography, Conventional Film and Self-Developing Film for Working Length Determination. 2018;13(3):381.
14. Hurstel J, Guivarc'h M, Pommel L, Camps J, Tassery H, Cohen S, Bukiet FJJoe. Do cell phones affect establishing electronic working length? 2015;41(6):943-6.
15. Gohil UK, Parekh VV, Kinariwala N, Oza KM, Somani MCJJocJ. Can active signals of cellphone interfere with electronic working length determination of a root canal in a dental clinic? An in vivo study. 2017;20(3):170.
16. Sidhu P, Shankargouda S, Dicksit DD, Mahdey HM, Muzaffar D, Arora SJJoe. Evaluation of interference of cellular phones on electronic apex locators: An in vitro study. 2016;42(4):622-5.
17. Duran-Sindreu F, Stöber E, Mercadé M, Vera J, Garcia M, Bueno R, Roig MJJoe. Comparison of in vivo and in vitro readings when testing the accuracy of the Root ZX apex locator. 2012;38(2):236-9.
18. Herrera M, Ábalos C, Lucena C, Jiménez-Planas A, Llamas RJJoe. Critical diameter of apical foramen and of file size using the Root ZX apex locator: an in vitro study. 2011;37(9):1306-9.
19. Shabahang S, Goon WW, Gluskin AHJJoe. An in vivo evaluation of Root ZX electronic apex locator. 1996;22(11):616-8.
20. Briseño-Marroquín B, Frajlich S, Goldberg F, Willershausen BJJoe. Influence of instrument size on the accuracy of different apex locators: an in vitro study. 2008;34(6):698-702.
21. Stöber EK, de Ribot J, Mercadé M, Vera J, Bueno R, Roig M, Duran-Sindreu FJJoe. Evaluation of the Raypex 5 and the Mini Apex Locator: an in vivo study. 2011;37(10):1349-52.
22. Stöber EK, Duran-Sindreu F, Mercadé M, Vera J, Bueno R, Roig MJJoe. An evaluation of root ZX and iPex apex locators: an in vivo study. 2011;37(5):608-10.
23. Mancini M, Felici R, Conte G, Costantini M, Cianconi LJJoe. Accuracy of three electronic apex locators in anterior and posterior teeth: an ex vivo study. 2011;37(5):684-7.
24. Real DG, Davidowicz H, Moura-Netto C, Zenkner CdLL, Pagliarin CML, Barletta FB, de Moura AAMJOS, Oral Medicine, Oral Pathology, Oral Radiology,, Endodontology. Accuracy of working length determination using 3 electronic apex locators and direct digital radiography. 2011;111(3):e44-e9.
25. D'Assunção FLC, de Albuquerque DS, Salazar-Silva JR, de Queiroz Ferreira LC, Bezerra PMJOS, Oral Medicine, Oral Pathology, Oral Radiology,, Endodontology. The accuracy of root canal measurements using the Mini Apex Locator and Root ZX-II: an evaluation in vitro. 2007;104(3):e50-e3.
26. ELAyouti A, Kimionis I, Chu AL, Löst CJIej. Determining the apical terminus of root-end resected teeth using three modern apex locators: a comparative ex vivo study. 2005;38(11):827-33.
27. Chen E, Kaing S, Mohan H, Ting S-Y, Wu J, Parashos PJJoe. An ex vivo comparison of electronic apex locator teaching models. 2011;37(8):1147-51.
28. Ibarrola JL, Chapman BL, Howard JH, Knowles KI, Ludlow MOJJoe. Effect of preflaring on Root ZX apex locators. 1999;25(9):625-6.
29. Wang Y, Zhu X, Zhang C. Pulp revascularization on permanent teeth with open apices in a middle-aged patient. J Endod. 2015;41(9):1571-5.

Please cite this paper as: Parirokh M, Manochefrifar H, Abbott P, Borna R, Haghdoost AA. Effect of Various Electronic Devices on the Performance of Electronic Apex Locator. Iran Endod J. 2019;14(4): 278-82. *Doi:* 10.22037/iej.v14i4.23752.