Research Article

JRAD Journal of Research and Advancement in Dentistry

J Res Adv Dent 2020;10:2:269-275.

The Effect of Electromagnetic Waves on the Functionality of Different Apex Locators During Voice Call with 2G, 3G, 4G Mobile and Internet Call with WhatsApp Application

Dhanpal Sadan[1*] Udaya Kumar P[2] Rakesh Reddy Chukka[3] Bungari Naveen Kumar[4] Naresh Kumar K[5] Malati Devi B[6]

[1]PG Student, Department of Conservative Dentistry and Endodontics, SVS Institute of Dental Sciences, Mahbubnagar, Telangana, India.
[2]Professor, Department of Conservative Dentistry and Endodontics, SVS Institute of Dental Sciences, Mahbubnagar, Telangana, India.
[3]Reader, Department of Conservative Dentistry and Endodontics, SVS Institute of Dental Sciences, Mahbubnagar, Telangana, India.
[4]PG Student, Department of Conservative Dentistry and Endodontics, SVS Institute of Dental Sciences, Mahbubnagar, Telangana, India.
[5]Senior Lecturer, Department of Conservative Dentistry and Endodontics, SVS Institute of Dental Sciences, Mahbubnagar, Telangana, India.
[6]Reader, Department of Pedodontics and Preventive Dentistry, SVS Institute of Dental Sciences, Mahbubnagar, Telangana, India.

ABSTRACT

Background: With advancement in technology, usage of electronic apex locators (EALs) has become popular amongst endodontists owing to increased accuracy. Use of smart phones has also become indispensable. Exposure to Electromagnetic waves (EMWs) emitted by smartphones can disrupt the functioning of EAL devices.

Materials and Methods: Fifty human maxillary incisors with out fractures or carious lesions were used. Root ZX mini(J. MORITA Mfg. Corp, Japan) and Easy apex- apex locators(Henan Co.,Ltd china) were used to measure canal length. After access preparation, the working length was determined visually with a size 15 K-file under 2.5 x magnification using Loupes. The tooth was embedded in an alginate model. The working length was determined using EAL 1. without the cell phone in the proximity. 2. with the cell phone in 2G mode, 3. with the cell phone in 3G mode, 4. with the cell phone in 4G mode and 5. with the cell phone in internet calling mode. The values obtained were analyzed using Paired t-test and One way Analysis of Variance (ANOVA) with a significance level of 5%.

Results: The tooth exposed to EMWs emitted from cell phone, during 3G and 4G mode had no change in mean difference of the Canal length measurement as compared to the visual canal length measurement. Whereas tooth exposed to EMWs during 2G mode and internet whatsapp voice calling had significant difference in the canal length.

Conclusion: EMWs emitted from cell phone in 3G and 4G mode does not cause malfunction of the Easy apex and Root ZX mini apex locators except during conversation with 2G and Internet WhatsApp voice calling mode.

Keywords: Apex locators; canal length; cell phones; electromagnetic waves.

INTRODUCTION

The correct determination of working length (WL) is a crucial step in achieving success during root canal treatment.[1-2] Underestimation of WL may lead to insufficient debridement of the root canal and overestimation can cause damage to the periapical tissue. Both the situations may have negative ramifications on the healing potential of periapical tissues.[3] There are many ways of determining the working length. The various methods being, digital tactile sense, use of paper

Received: Oct. 12, 2019**: Accepted**: Dec. 27, 2019
***Correspondence Dr. Dhanpal Sadan.**
Department of Conservative Dentistry and Endodontics, SVS Institute of Dental Sciences, Mahbubnagar, Telangana, India.
Email: Not Disclosed

pISSN 2278-0076
eISSN 2321-9270

points to gauge the apical bleeding, patient's response to instrument placement in the canal till the apex, without administering local anesthetics, and radiographic interpretation. But all these methods have some limitations. Most of these limitations are overcome by electronic apex locators (EAL).[4-5]

The EALs determine not only the location of apical foramen but also the apical constricton.[6-7]Electronic communication devices are widely used at present in day today life. In appropriate performance of some medical devices has been reported due to electromagnetic interference arising out of these electronic devices such as smart phones, iPod, iPad etc. Therefore, the use of these gadgets is restricted to spaces other than the operatory areas.[8-9] However, in dental offices no such restrictions have been imposed. The use of cell phones either by the doctor or the auxiliary staff can influence the accuracy of the device.

EAL has certain limitations in regard to the accuracy. Usage of different irrigants, preflaring and use of wrong file size could be responsible for minor errors in the reading. Another major possibility of inaccuracy in the reading might be due to the electromagnetic interference (EMI) in the form of EMWs originating from mobile phones on the EAL.[10-12]

Mobile phones have been classified as 1G, 2G, 3G and 4G based on the mobile network technology. The second-generation of cell phone (2G) uses the Global System for Mobile Communications (GSM) [13] and was first launched in Finland in 1991. Its data transfer rate is 500 kilobit/sec (kbps). Third generation (3G) mobile network technology included multimedia, based on Code Division Multiple Access (CDMA) technology and Wide-band CDMA (WCDMA)[14] which was introduced in Japan in October 2001. The average data transfer rate is 2000kbps and operational frequency is 2100 megahertz (MHz).

Fourth generation (4G) is the new generation of mobile network technology based on Long Term Evolution (LTE). The average data transfer rate is 10000kbps and frequency is 1800 mega-hertz (MHz).[14] There are about 550 million internet users in India making it the second largest online population in the world. Free internet calling services which works on 4G or Wi-Fi which emits higher radiation than normal phone calling services and could be a health hazard, yet it is still widely used because of economic reasons.[15]

Since apex locators are electronic devices, they can also be subjected to EMI. Hence, the purpose of this study was to evaluate the effect of electromagnetic waves on the functionality of apex locators during voice call by mobile phones in 2G,3G,4G modes and during What's App calling using mobile communication network.

The null hypothesis tested was that electromagnetic waves do not affect the functionality of apex locators, during the use of 2G/3G/4G and whatsapp calling with mobile phones in close proximity.

MATERIALS AND METHODS

Fifty, single canal (Vertucci's type I), maxillary incisors extracted for periodontal purpose were used in this study. Approval was taken from Institutional ethical committee for use of extracted teeth. The exclusion criteria were, endodontically treated teeth, calcification, open apex, internal or external resorption, root fracture, and any severe root canal curvatures. External root surface debris and contaminants were removed using the scaler (Dentafix, United Kingdom) and stored in distilled water at 4°C until usage to maintain their hydration.[16] Access cavity preparation was done using round diamond burs (Dentsply Maillefer, Switzerland) and refined with an Endo-Z bur (Dentsply Maillefer).

In order to obtain a stable and repeatable incisal reference, crown of each tooth was cut using a diamond disc (Stoddard, United Kingdom) from 5mm above the cement enamel junction.[17] A size 10 K-file (Dentsply, United States) was used to confirm patency. The canal was irrigated with 3% sodium hypochlorite solution.[18] A code was assigned to each tooth before visual canal length measurement to blind the investigator. EWL was performed using two different EALs:

1. Root ZX mini apex locator (J. MORITA Mfg. Corp, Japan) a third-generation EAL and dual frequency device (0.4 and 8.0 kHz), based on the ''quotient method'' principle (i.e., calculating the canal impedance by the ratio of the two frequencies simultaneously); the quotient of the impedances

decreases quickly as the apical constriction is reached.[19]

2. Easy apex locator(Henan co.,Ltd china)a sixth-generation EAL.

The communication device used in this experiment was Redmi 4 MAI132 (XIAOMI, Beijing China), mobile phone using three different settings. The device was set on the network "GSM only" for 2G, "WCDMA only" for 3G and "VOLTE" for 4G.

During all the experiments, Wi-Fi and Bluetooth connections were inactivated, and no other cell phones were present in the operatory. All EWL determinations were performed in the same place to ensure that the signal intensity of the cell phone reception was stable. A dental office in a hospital building with a weak incoming signal was selected for conducting the experiments.

To measure the actual visual length, a size15 K-file was inserted into the root canal until the file tip became visible at the apex. Later, the file was slowly pulled back so that its tip was placed at the apical foramen. This was checked by using loupes and moving an explorer on the root tip. The rubber stop was carefully adjusted to the reference point and stabilized with Cyanoacrylate resin (Razi chemicals, Iran). The distance between the rubber stop and the file tip was measured using a digital Vernier caliper (Mitutoyo Corp, Japan) with 0.02mm accuracy.

For electronic canal length measurement, roots were embedded in an alginate model, so that the first 3mm of the cervical third was projecting out of alginate. All measurements were performed within 2-hour interval.[20] A size 15 K-file was connected to the file clip of the apex locator and was inserted into the root Canal. It was carefully withdrawn once the display unit showed zero reading and gave an audible beep signal for 5 seconds. The rubber stop was adjusted and stabilized with cyanoacrylate resin on the specimen, and the canal length was measured by digital Vernier caliper. Cell phones on active mode (ON) were placed in close proximity to the EAL (5 cm distance between the EAL and the phone), and the canal length was measured under four different following conditions.

1. Measurements during 2G phone in conversation mode,
2. Measurements during 3G phone in conversion mode.
3. Measurements during 4G phone in conversion mode.
4. Conversation during 4G phone in what's app voice call.

The duration of conversation was for 10 minutes. Measurements were done during this period. In case of fluctuations in the readings, the file was held in position for 1 minute to achieve a stable reading and then the stopper was positioned.

STATISTICAL ANALYSIS

Data was analysed with the Statistical Package for the Social Sciences (SPSS) version 21 (IBM Corp. Released 2012. IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY: IBM Corp). The following tests were used: Paired t-test, Oneway Analysis of Variance (ANOVA) with a significance level of 5%.

RESULTS

Canal Length (CLs) of 50 maxillary incisors was compared at different conditions. The mean and standard deviation (SD) of visual canal length to the apex was 22.30 ± 1.46 mm. The mean and SD of EAL in the absence of EMWs was 22.42 ± 1.42 mm of Root ZX and 22.46± 1.48 mm of Easy apex(paired t-test). [Table 1 & 2]

The conversation with 2G showed lower mean CL, whereas the conversation with What's app call group showed higher CL than normal (21.80 ± 1.44, 21.36 ± 1.50 and 22.78 ± 1.54, 22.90 ± 1.52 respectively) in both the apex locators.

The mean CL in the presence of EMWs in all conditions was not significantly different compared with visual CL and in the absence of EMWs group.

DISCUSSION

EALs are widely used in endodontics because of its accuracy but could produce erroneous results in case of interference by other electronic devices. Smartphone usage by the general population has grown leaps and bounds in recent years. According to a worldwide survey in 2017, 7 billion people own a mobile phone, representing the majority of the world's population today.[21]

Table 1: Comparison of the mean CL with EAL in the presence of EMWs at different conditions and in the absence of investigated EMWs of Root ZX Mini.

GROUP	NUMBER	MAXIMUM CL(mm)	MINIMUM CL(mm)	MEAN ± SD (mm)
Visual CL	50	25.57	20.02	22.30 ± 1.46
CL with EAL and absence of EMWs	50	26.34	20.12	22.46 ± 1.48
CL with EAL and 2G	50	25.04	20.10	21.36 ± 1.50
CL with EAL and 3G	50	25.78	20.46	22.32 ± 1.44
CL with EAL and 4G	50	25.64	20.44	22.30 ± 1.42
CL with EAL and during Whats App	50	26.24	21.34	22.90 ± 1.52
P-value*				0.844

CL, Canal length; EAL, electronic apex locators; EMWs, Electromagnetic waves; SD, Standard deviation; P-value; *repeated-measure ANOVA

Table 2: Comparison of the mean CL with EAL in the presence of EMWs at different conditions and in absence of investigated EMWs of Easy apex.

GROUP	NUMBER	MAXIMUM CL(mm)	MINIMUM CL(mm)	MEAN ± SD (mm)
Visual CL	50	25.57	20.02	22.30 ± 1.46
CL with EAL and absence of EMWs	50	25.50	19.99	22.42 ± 1.42
CL with EAL and 2G	50	25.01	19.71	21.80 ± 1.44
CL with EAL and 3G	50	25.48	20.01	22.32 ± 1.40
CL with EAL and 4G	50	25.49	19.99	22.34 ± 1.44
CL with EAL and during Whats App	50	26.18	20.44	22.78 ± 1.54
P-value*				0.832

CL, Canal length; EAL, electronic apex locators; EMWs, Electromagnetic waves; SD, Standard deviation; P-value; *repeated-measure ANOVA

The technical support documents of several EALs state that EMI from portable and mobile radiofrequency communication equipment can cause interference with an accurate reading of the EAL. The safety profile of the smartphones is still unknown for many medical devices and furthermore, digital mobile phones may emit higher strength electromagnetic fields than analogue mobile phones. The growing use of multiple communication networks caused concerns regarding interference with electronic devices. Such interactions are documented by various investigators.[10]

In the present study, the electromagnetic interaction of mobile phones used in 2G,3G,4G mode during voice calling and internet calling with whatsapp on EALs were evaluated. The EMI increases when the mobile phone is ringing and during calling mode due to the increased intensity

of wave emission. [22] Conversation using 2G and Internet calling in close proximity with EASY APEX and Root ZX mini apex locator influenced significantly on the readings of the device. Therefore, the null hypothesis tested was rejected and electromagnetic waves do affect the functionality of apex locators, during the use of smart phones in close proximity. Sidhu et al [11] evaluated the effect of a Samsung Galaxy Note Edge smart phone on WL determination of Propex II and Rootor EALs and the authors concluded that EWL measurements were not influenced by the presence of a mobile phone and could be determined under all experimental conditions. Hurstel et al [12] evaluated the effect of an Apple iPhone 5 or LG KP100 mobile phone placed in direct contact with a Dentaport Root ZX (J Morita, Japan) module or Propex II (Dentsply-Maillefer,Switzerland) on WL determination and the authors concluded that neither the mobile phone type nor the EAL affected the measurements.

Gohil et al [23] evaluated the effect of interference of iPhone 6s and Xolo Q3000 cell phones on WL determination of Propexpixi and root ZX mini EALs at a distance of 2 feet between cellphone and the apex locator and the authors concluded that cellphones do not interfere with the EWL determination but interference arising out of voice call using internet was not evaluated.

The results of present study did not show a significant difference in the canal length in comparison to visual model and conversation mode using phone, except in the case of conversation with 2G and What'sApp calling. Apparently, conversation with 2G signal receives far greater amount of radiation than 3G and 4G signals (on an average 28 times). This is because the phones in 2G mode transmit at full power when trying to connect, which could be around a maximum power of 2W, to periodically maintain contact with the nearest mobile antenna. On the other hand, 3G and 4G phones emit minimum radiation to maintain the connection as they consume a maximum power of only 125 - 250 mW.

Currently, WhatsApp application has more than 1.3 billion users making it the most popular messaging application. It has also primed on to free international calling services. According to Eastern broadcasting, the electromagnetic waves of mobile phone is 320 W. While using dial function it is 92,000W and while using the call function of WhatsApp, the EMW increases to 3,20,000W.[24] This increase in EMW could be the reason for interference in the functioning of the EALs leading to change in CL reading.

In addition to periodontium simulation, a gel-like consistency, simplicity, ease of use, easy access, and cost-effectiveness are the other reasons that the alginate was chosen as the embedding media for the present study. Guerreiro-Tanomaru's [20] study in 2011 showed that alginate is a better test environment in comparison with saline. Lipski et al. did not observe any significant difference between the measured electrical CL in the mouth and alginate test environment.

To eliminate the bias on use of many cell phone models, one model of phone Redmi 4 MAI132 (XIAOMI, Beijing China) in three different network modes of GSM only (2G), WCDMA only (3G) and VOLTE only (4G) was used. in present study as the primary objective was to ascertain the influence of different generations of mobile networks on the functioning of the apex locator rather than the mobile phones per se.

CONCLUSION

Within the limitations of the present study, it was found that EMWs of 3G and 4G does not cause malfunction of the readings in Easy apex and Root ZX mini apex locators.Whereas, conversation with 2G and internet calling (WhatsApp) mode at close proximity results in discrepancy of the readings of apex locator.

CONFLICTS OF INTEREST

The authors declare they have no potential conflict of interests regarding this article.

REFERENCES

1. Bernardes RA, Duarte MA, Vasconcelos BC, et al. Evaluation of precision of length determination with 3 electronic apex locators: Root ZX, Elements Diagnostic Unit and Apex Locator, and RomiAPEX D-30. Oral Surg Oral Med Oral Pathol Oral RadiolEndod 2007;104:e91–e94.

2. Angwaravong O, Panitvisai P. Accuracy of an electronic apex locator in primary teeth with root resorption. IntEndod J 2009;42:115–121

3. Apical limit of root canal instrumentation and obturation, part 2. A histological study. IntEndod J 1998;31:394–409.

4. McDonald NJ. The electronic determination of working length. Dent Clin North Am 1992;36:293-307.

5. Martins JN, Marques D, Mata A, Carames J. Clinical efficacy of electronic apex locators: Systematic review. J Endod 2014;40:77.

6. Mosleh H, Khazaei S, Razavian H, Vali A. Electronic apex locator: A comprehensive literature review—Part I: Different generations, comparison with other techniques and different usages. Dent Hypotheses 2014;5:84-97.

7. Lioyd A, Ingle JI. Electronic apex locators. In: Ingle JI, Bakland LK, Baumgartner JC, editors. Ingle's endodontics 6. BC DecerInc; 2008. p. 853.

8. Nojima T, Tarusawa Y. A new EMI test method for electronic medical devices exposed to mobile radio wave. Electron CommJpn 1 2002;85:11–18.

9. Klein AA, Djaiani GN. Mobile phones in the hospital – past, present and future. Anaesthesia 2003;58:353–357.

10. Patel MB, Thaker JP, Punnam S, Jongnarangsin K. Pacemaker interference with an iPod. Heart Rhythm 2007;4:781–784.

11. Sidhu P, Shankargouda S, Dicksit DD, Mahdey HM, Muzaffar D, Arora S. Evaluation of interference of cellular phones Electronic apex locators: An in vitro study. J Endod 2016;42:622–625.

12. Hurstel J, Guivarc'h M, Pommel L, et al. Do cell phones affect establishing electronic working length? J Endod 2015;41:943–946.

13. Silberberg JL. Performance degradation of electronic medical devices due to electromagnetic interference. Compliance Engineering 1993;10:1-8.

14. Guo L, Zhang J, Maple C. Coverage and Capacity Calculations for 3G Mobile Network Planning. proc PGNET 2003;2003: 16-7.

15. Joshphin J, 4G Mobile communications - Emerging Technologies. Ijmas 2015;109:114-119.

16. Brito-Júnior M, Camilo C, Moreira-Júnior G, Pecora J, Sousa-Neto M. Effect of pre-flaring and file size on the accuracy of two electronic apex locators. J Appl Oral Sci 2012;20:238-43.

17. Teixeira J, Barcellos M, Pinho M, Barbosa C, Fidel R, Fidel S. Effectiveness of an electronic apex locator used after preflaring of cervical and middle third. RSBO 2012;9:158-62.

18. Carvalho AL, Moura-Netto C, Moura AA, Marques MM, Davidowicz H. Accuracy of three electronic apex locators in the presence of different irrigating solutions. Braz Oral Res 2010;24:394-8.

19. Gordon MP, Chandler NP. Electronic apex locators. IntEndod J 2004;37:425–37.

20. Guerreiro-Tanomaru JM, Croti HR, Silva GF, Faria G, Tanomaru- Filho M. Tooth embedding medium influences the accuracy of electronic apex locator. ActaOdontolLatinoam 2012;25:214-7.

21. Statista – The statistics portal. Number of mobile phone users worldwide from 2012 to 2018 (in billions). Available at: http://www.statista.com/statistics/274774/forecast-ofmobile- phone-users-worldwide/. Accessed: 12 August 2015.

22. Baranchuk A, Kang J. Electromagnetic Interference of Communication Devices on ECG Machines. Clin. Cardiol 2009;32,10;588-592.

23. Gohil UK, Parekh VV. Can active signals of cellphone interfere with electronic working length determination of a root canal in a dental clinic? An *in vivo* study: J Conser Dent 2017;20:3;170-73.

24. Whatsapp call function may cause high electromagnetic waves Available at: http://www.lifewire.hk/en/Whats-

New/Health-Lifestyle/Whatsapp-Call-Function.html.