Journal of Applied Dental and Medical Sciences
NLM ID: 101671413 ISSN:2454-2288
Volume 6 Issue 1 Jan-March 2020

Original Research

Electromagnetic interference of communication devices on apex locators: An in vitro study

Juili Gawande[1], Tarun Ahuja[2], Kranthikumar Reddy S[3], Zinnie Nanda[4], Parth More[5], Nikhil Mahanubhav[6]

[1]*Post Graduate Student, Dept of Conservative Dentistry and Endodontics, A.C.P.M Dental College and Hospital, Dhule, India*
[2]*Professor, Dept of Conservative Dentistry and Endodontics, A.C.P.M Dental College and Hospital, Dhule, India*
[3]*Reader, Dept. of Conservative Dentistry and Endodontics, A.C.P.M Dental College and Hospital, Dhule, India*
[4]*Professor and Head, Dept. of Conservative Dentistry and Endodontics, A.C.P.M Dental College and Hospital, Dhule, India*
[5]*Post Graduate Student, Dept of Conservative Dentistry and Endodontics, A.C.P.M Dental College and Hospital, Dhule, India*
[6]*Post Graduate Student, Dept. of Conservative Dentistry and Endodontics, A.C.P.M Dental College and Hospital, Dhule, India*

ARTICLE INFO

Keywords:
Electronic apex locator, electromagnetic waves, cell phone, working length

ABSTRACT

Introduction: Accurate resolution of working length plays a vital role in endodontic therapy. Generally, the electronic apex locators are used more because of high accuracy and convenience when compared to other methods. As electronic apex locators (EAL) use the electronic method, it is possible that electromagnetic waves (EMW) affect their performance.

Aim: to check the effect of electromagnetic waves on efficiency of electronic apex locator.

Material and Methodology: the canal length of 10 maxillary incisors (vertucci type I) was measured with 15 k file. Root ZX mini and Apex ID locators were used to measure working length in a circuit of electromagnetic waves in both 2G and 3G mobile communication network at a distance of 40 cm. and in close contact with apex locators.

Results: there is no significant change in measurement of readings when compared with mobile phone in different conditions ($P > .05$).

Conclusion: the accuracy of the EALs (Root ZX mini or Apex ID) were not influenced when placed in direct contact with a smart phones of second and third generation.

INTRODUCTION

Preservation of what remains in human dental arch is of utmost importance than meticulous replacement. With the growing awareness and concern of the population towards there dentition, root canal therapy has now become an integral part of dental practice. The secret of healing of an endodontic lesion depends on various factors among which correct working length estimation remains a crucial step[1]. Several approaches have been proposed for determining the working length like dentist's knowledge of the apical anatomy, tactile sense, apical bleeding, patient response without anesthetics and radiographic interpretation[2]

Because of the limitations of these methods, efforts continued to find a way to determine the exact working length. With advancement in technology, usage of electronic apex locators (EALs) has raised among practitioners owing to increased accuracy and reduced exposure to radiation.[3] In comparison with radiography, the new apex locators determine not only the location of apical foramen but also the apical constrictor.[4,5]

* Corresponding author***: Juili Gawande,*** *Post Graduate Student, Dept of Conservative Dentistry and Endodontics, A.C.P.M Dental College and Hospital, Dhule, India*.

Root ZX mini apex locator from the third generation of apex locators simultaneously measures the impedances of two different frequencies (0.8 and 4 KHz) and provides apex location based on the resulting quotient. This device makes it possible to measure length with high precision.[2] Apex ID on the other hand is sixth generation of apex locator. The manufacture claims that the impedance of the electric circuit may be changed depending on the distance between the end of a file and the apex of the root canal, which results in a change in the micro signals that are input back into the unit.[6]

Various factors such as correct usage, presence of irrigants, vital or necrotic pulp, inflammatory exudate and obturating material in the root canal, contribute to the accuracy of electronic apex locators.[1]

It is a well-known fact that electromagnetic radiation emitted from devices such as cellular phones, iPods and dental devices such as electronic pulp testers, electro surgery units and ultrasonic scalers can interfere with the function of implanted cardiac pacemakers in patients with implanted cardiac devices. [7-9]

Studies have reported that cellular phones can inhibit the function of a pacemaker and this depends on the distance between the pacemaker and the electronic device, power output of the electronic device, type of pacemaker, age of pacemaker, and model of the cellular phone. Therefore it is suggested that the use of cellular phones should be restricted in hospitals because electromagnetic interference (EMI) caused by cellular phones can interfere with functions of medical devices.[10-12]

Various studies have been conducted which described the effect of electromagnetic radiation on different devices. One of the very pervasive electromagnetic wave (EMW) with controversial interactions are waves used in mobile communication networks. Electrical energy from these dental devices can travel down the lead wires and can induce ventricular or atrial fibrillation and reprogram the cardiac device. This study was conducted with the aim to check the effect of electromagnetic radiation mainly by 2G and 3G mobile network on electronic apex locator.

MATERIAL AND METHODOLOGY:

In this in-vitro study, 10 single-canal (Vertucci's type I) maxillary central incisors, which were extracted due to periodontal disease or severe decay, were collected. The exclusion criteria were previous endodontic treatment, calcification, open apex, internal or external resorption, root fracture, and any severe root canal curvatures. External root surface debris and contaminants were removed using ultrasonic scaler.[2]

In order to obtain a stable and repeatable incisal reference, crown of each tooth was cut by a diamond disc at the cementoenamel junction.[2] A 10 kfile (Dentsply, New York, United States) was used to confirm patency.[13] To measure the actual visual length, a 15 k-file was inserted into the root canal until the file tip became visible at the apical foramen. The file was then slowly pulled back so that its tip was placed at the apical foramen. This situation was checked by observing with moving an explorer on the root tip. The rubber stop was carefully adjusted to the reference point and was stabilized.[13] Then the distance between the rubber stop and the file tip was measured by a caliper.

Each tooth was than inserted into the cylinder containing normal saline. Each tooth was fixed using rubber sheet. A 15 k-file was inserted into the root canal. Then the lip electrode was immersed in the embedding media and the other electrode was connected to the file. The file was slowly inserted into the apical direction until the OVER sign appeared on the device's display and then gently retracted to the "ZERO" or "APEX" signal. The two

different apex locators used in this study were Root ZX mini by J Morita and Apex id by Sybron Endo.

Measurements were identified if the device stayed stable for at least 5 seconds. After this, the rubber stop was carefully adjusted to the reference point and distance between the stop and file tip was measured by caliper with 0.02mm accuracy.[13]

The communication device used in this experiment was one plus 5 for 3G network and Nokia 105 for 2G network. Cell phones on active mode (ON) were placed at direct contact and 40 cm away from the EAL and the canal length with EAL was measured. Other mobile communication features such as Bluetooth, Wi-Fi, Mobile data and Global Positioning System (GPS) were on throughout the procedure. At the time of the instability of apex locator indicator on the apex sign, at least 1 minute was determined to achieve the stability of device indicator. The experiment was divided into following groups

- Group I - Root ZX mini at distance of 40 cm to 3G smart phone when Bluetooth and Wi-Fi is activated (Fig. 1)
- Group II- Root ZX mini in close approximation with 2G phone when Bluetooth is activated (Fig. 2)
- Group III- Apex ID at distance of 40 cm to 3G smart phone when Bluetooth and Wi-Fi is activated (Fig. 3)
- Group IV - Apex ID in close approximation with 2G phone when Bluetooth is activated (Fig. 4)

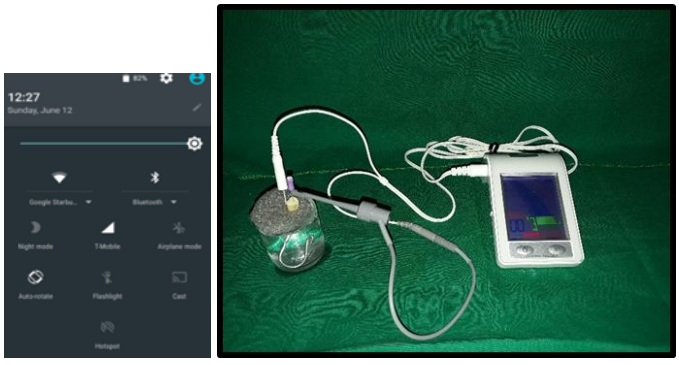


Figure 1: Group I - Root ZX mini at distance of 40 cm to 3G smart phone when Bluetooth and Wi-Fi is activated

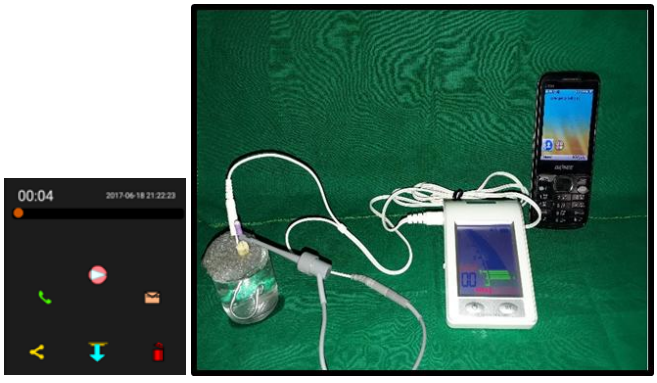


Figure 2: Group II - Root ZX mini in close approximation with 2G phone when Bluetooth is activated

Figure 3: Group III - Apex ID at distance of 40 cm to 3G smart phone when Bluetooth and Wi-Fi is activated

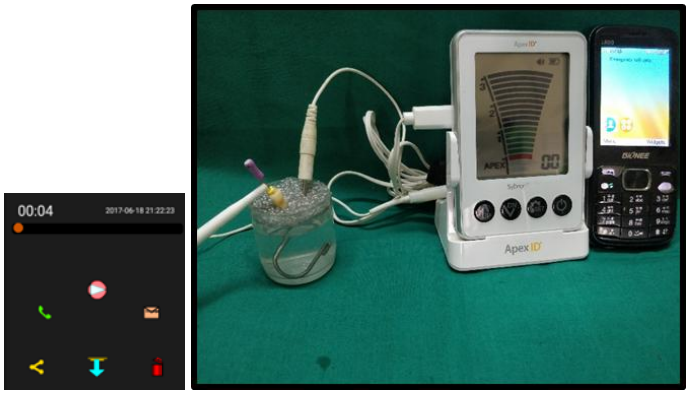


Figure 4: Group IV - Apex ID in close approximation with 2G phone when Bluetooth is activated

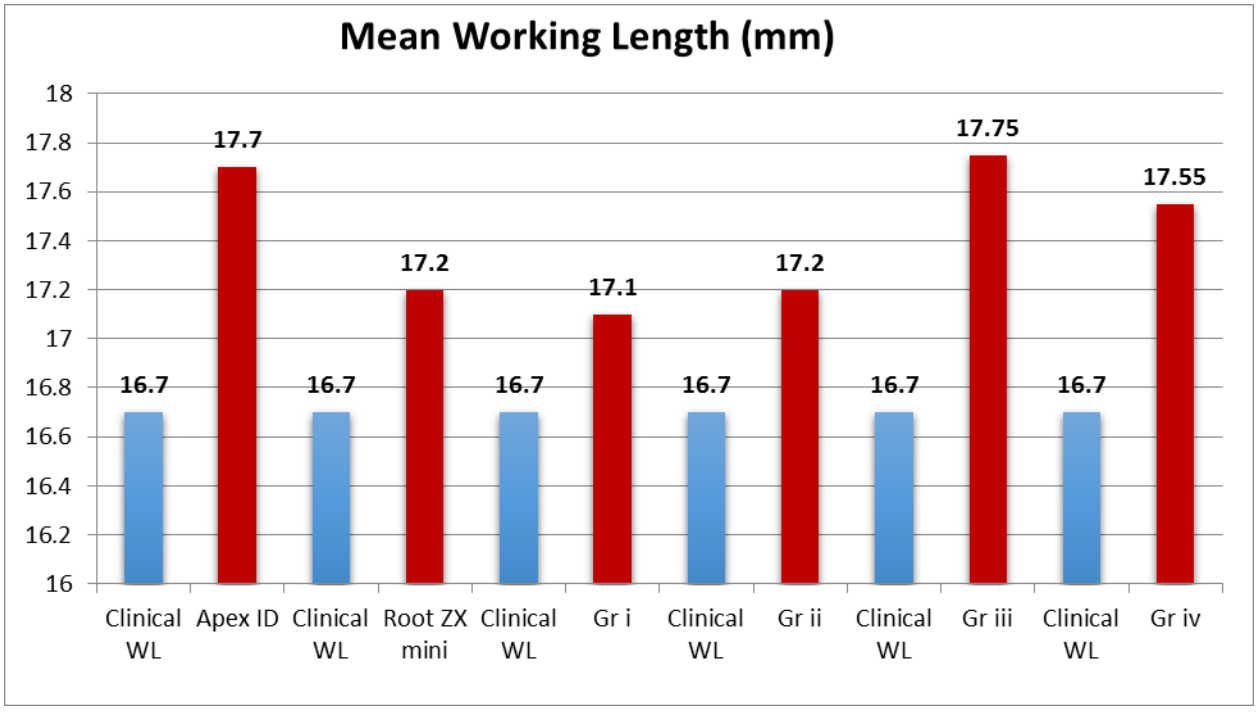
The measurement process was repeated once again in these cases. Data were analyzed by the Statistical Package for the Social Sciences (SPSS) version 21. The test used was unpaired t test.

RESULT

Three readings were taken for each tooth, and averages of the readings were tabulated and compared for mean and standard deviation under the different conditions. It was found that in a closed room among the different apex locators, there is no significant change in measurement of readings when compared with mobile phone in different conditions ($P > .05$). No statistically significant differences were recorded between the different groups. (Table 1, graph 1)

Table 1: Mean working length

Groups	Mean	Std. Deviation	Mean difference	t value	p value
Clinical WL	16.700	1.6193	-1.00	-1.496	0.152
Apex ID	17.700	1.3581			
Clinical WL	16.700	1.6193	-0.50	-0.690	0.499
Root ZX mini	17.200	1.6193			
Clinical WL	16.700	1.6193	-0.40	-0.566	0.579
Group I	17.100	1.5420			
Clinical WL	16.700	1.6193	-0.50	-0.690	0.499
Group II	17.200	1.6193			
Clinical WL	16.700	1.6193	-1.05	-1.551	0.138
Group III	17.750	1.3994			
Clinical WL	16.700	1.6193	-0.85	-1.278	0.218
Group IV	17.550	1.3427			



Graph 1: Mean working length

DISSCUSSION

With the advent of technology, electronic market is flooded with new smartphones. These smartphones has now become a necessity of a common man. According to a worldwide survey, in 2015, 4.9 billion people own a mobile phone, representing more than half of the world's population today.[14] Electromagnetic radiation between cellular phones and medical devices generally occurs only when the cellular phones are in proximity to the medical devices.[15] But the result of this study says that there is no correlation between cellular phone use and electronic working length (EWL) determination.

Various In vitro studies have used alginate, agar agar, gelatin, and saline to simulate the root surrounding tissues in EWL determination. So in present study normal saline was used as an electro conductive material.[16, 17] The accuracy of EALs could affected by foramen diameter.[18] The maxillary central incisors were used in present study whereas Hurstel et al. used premolar teeth. Premolar teeth have the most and the largest accessory foramens as well as the most complicated apical morphologic makeup. It would be a possible reason for the failure of root canal therapy in premolar teeth. Teeth were horizontally sectioned at the cementoenamel junction for obtaining reproducible reference points and were mounted in a plastic container.[1] Ease and determining the length with the EALs, as well as the higher accuracy rather than the conventional radiographic method, has led to the popularity of using these devices among practitioners.[2]

In the present study electronic apex locators used were Root ZX mini and Apex ID. The Root ZX mini (J. Morita Corporation) is a third generation EAL that uses the 'ratio method' to calculate the root canal length. It is considered as the gold standard to which the newer apex locators are being compared. According to previous studies, its accuracy varies from 50% to 100%. The manufacturers claim that Root ZX mini is accurate, even in the presence of electrolytes, such as sodium hypochlorite, saline, tap water or hydrogen peroxide.[19,20,21] The sixth generation EAL's: Apex ID (SybronEndo) and CanalPro (ColteneEndo) are based on dual frequencies that are sent from and returned to the unit after travelling along the electric circuit.[22] The accuracy of Sybron ApexID was 100% and similar to an earlier study of 97.5% accuracy using NaOCl as an irrigant by De Camargo et al.[23] The accuracy of Sybron ApexID using NaOCl is believed to be because of its multifrequency mechanism and shorter transmission line.[22] Therefore Root ZX mini and Apex ID were chosen apex locators for the study.

The growing use of communication networks caused concerns regarding interference with other electronic devices. Such interactions have been proved by some previous investigations.[2] In the present scenario 2nd generation mobile phones (2G) are replaced by 3rd generation. In the present study influence of 2G and 3G phone was checked on two apex locators mainly Root ZX mini and Apex ID.

EMI is broadly defined as any unwanted electromagnetic energy that causes undesirable response, degraded performance or failure in electronic equipment. Because the distance between two electronic devices can influence EMI, different distances between the cellular phone and the EAL were tested in this study.[24] Because the ideal distance between a dental operator and a patient is similar to that of reading a book, a distance of 40 cm between the apex locators and the cellular phone was used in this study similar to the study performed by Sidhu et al. EMWs radiation is found to be very high in the conversation condition, particularly for the 2G connection compared to 3G. According to Hurstel J et al.

as the wave emission is intense during the calling mode of the cellular phone the calling mode was used to maximize the chances of detecting EMI and same reason for WIFI and Bluetooth activation for 3G phone. According to an earlier study's finding, EALs are likely not powerful enough to trigger EMI with pacemakers except when the EALs were placed close to the tip of the pacemaker's electrode or close to the generator. This hypothesis may also explain the absence of EMI between EALs and cell phones.[25]

The findings of this study do not support the claim in the user manuals of EALs that EMI from portable and mobile radiofrequency communications equipment such as cellular phones can cause interference with accurate reading of the apex locator which were found to be similar to the study performed by Hurstel J et al in 2015 and sidhu et al in 2016.

CONCLUSION

Within the limitations of the present study, the following can be concluded:

1. The reliability and stability of the EALs (Root ZX mini or Apex ID) were not influenced when placed in direct contact with a smart phone (One plus 5) or a GSM phone (Nokia 105).

2. Patients or dentists may keep their cell phones in the treatment room during an endodontic therapy without disturbing EWL determination.

-

REFERENCES

1. Sidhu P, Shankargouda S, Dicksit DD, Mahdey HM, Muzaffar D, Arora S. Evaluation of interference of cellular phones on electronic apex locators: An in vitro study. Journal of endodontics. 2016; 42(4):622-5.
2. Shafieibavani M, Iranmanesh P, Iranmanesh F. Evaluating electromagnetic interference of communication devices with root ZX mini apex locator. Dental Hypotheses. 2016; 7(4):142.
3. Martins JN, Marques D, Mata A, Carames J. Clinical efficacy of electronic apex locators: Systematic review. J Endod. 2014; 40:759-77.
4. Plotino G, Grande NM, Brigante L, Lesti B, Somma F. Ex vivo accuracy of three electronic apex locators: Root ZX, Elements Diagnostic Unit Apex Locator and ProPex. Int Endod J. 2006; 39:408-14.
5. 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.
6. Apex ID brochure
7. Hayes DL, Wang PJ, Reynolds DW et al. Interference with cardiac pacemakers by cellular telephones. N Engl J Med. 1997; 336:1473-9.
8. Patel MB, Thaker JP, Punnam S et al. Pacemaker interference with an iPod. Heart Rhythm. 2007; 4:781-4.
9. Miller CS, Leonelli FM, Latham E. Selective interference with pacemaker activity by electrical dental devices. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 1998; 85:33-6.
10. Tandogan I, Temizhan A, Yetkin E et al. The effects of mobile phones on pacemaker function. Int J Cardiol. 2005; 103:51-8.
11. Trigano JA. Interferences and cardiac pacemakers-defibrillators: results of in vivo experiments and radio frequencies. Arch Mal Coeur Vaiss. 2003; 96(Spec No 3):42–5.
12. Baranchuk A, Kang J, Shaw C et al. Electromagnetic interference of communication

devices on ECG machines. Clin Cardiol. 2009; 32:588-92.

13. 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.
14. Silva EJ, Muniz BL, Carvalho NK, Sassone LM, de Almeida Neves A. Electromagnetic interference of smartphones on apex locators: An in vivo study. ENDO (Lond Engl). 2016; 10(3):161-5.
15. Klein AA, Djaiani GN. Mobile phones in the hospitals: past, present and future. Anaesthesia. 2003; 58:353-7.
16. Barthelemy J, Gregor L, Krejci I et al. Accuracy of electronic apex locatercontrolled handpieces. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2009; 107:437-41.
17. Altunbas D, Kustarci A, Arslan D et al. Comparison of various current electronic apex locators to determine the working length using the clearing technique. Niger J Clin Pract. 2015; 18:359-63.
18. Hurstel J, Guivarc'h M, Pommel L, Camps J, Tassery H, Cohen S et al. Do Cell Phones Affect Establishing Electronic Working Length J Endod. 2015; 41:943-6.
19. Kobayashi C, Suda H. New electronic canal measuring device based on the ratio method. J Endod. 1994; 20:111-114.
20. Mull JP, Manjunath V, Manjunath M. Comparison of accuracy of two electronic apex locators in the presence of various irrigants: An *in vitro* study. J Conserv Dent. 2012; 15:178-182
21. Kielbassa AM, Muller U, Munz I, Monting JS. Clinical evaluation of the measuring accuracy of ROOT ZX in primary teeth. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2003; 95:94-100.
22. Taneja S, Kumar M, Sharma SS, Gogia H. Comparative Evaluation of Accuracy of Three Electronic Apex Locators in Different Simulated Clinical Conditions-An invitro Study. Annals of Medical and Health Sciences Research. 2017, 7(3).
23. De Camargo EJ, Zapata RO, Medeiros PL, Bramante CM, Bernardineli N, Garcia RB et al. Influence of preflaring on the accuracy of length determination with four electronic apex locators. J Endod. 2009; 35:1300.
24. Mathur P, Raman S. Electromagnetic Interference (EMI): Measurement and Reduction Techniques. Journal of Electronic Materials. 2020, 1-24.
25. Hurstel J, Guivarc'h M, Pommel L, Camps J, Tassery H, Cohen S, Bukiet F. Do cell phones affect establishing electronic working length? Journal of endodontics. 2015; 41(6):943-6.