

Evaluation of Electromagnetic Interference of Smartphone on Apex Locators: An in Vivo Study

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ABSTRACT

Introduction: The apical constriction where the pulp is linked to the apical periodontal tissue referred to as the minor diameter is recommended by many as the appropriate landmark where root canal preparation and obturation should terminate. The traditional method used to determine working length (WL) is based on the radiographic visualization of an instrument placed in the canal. These electronic apex locators can be affected by electromagnetic interference by the cell phones radiation. Hence, the present study was conducted to check the effect of cell phone radiation on electronic apex locator.

Aim and Objectives: To evaluate the interference of active cellphones during electronic working length (EWL) determination of a root canal.

Materials and Methods: forty patients requiring root canal treatment in the anterior teeth or premolars having single canal and mature apices were selected for this study. Working length determination was done using no. 15 K-file. Electronic apex locators Raypex 6 and Root ZX mini were used for working length determination. Cellphones iPhone 6s was evaluated for their interference. The experiment was conducted in a closed room (9 feet × 9 feet). Stability of the readings was also determined for every condition.

Statistical Analysis: The data were statistically analyzed using one-way ANOVA and paired t-test at 0.05 level of significance.

Results: Results were not statistically significant.

Conclusion: Cellphones do not interfere with the EWL determination under all four experimental conditions.

Keywords: electronic working length, electromagnetic interference, Raypex 6, Root ZX mini

INTRODUCTION

The success rate of endodontic treatment depends on determining the correct working length.¹ Several approaches have been proposed for determining the working length:² apical anatomy, tactile sense, apical bleeding, patient response without anesthetics, and radiographic interpretation.³ However, all these methods have certain limitations.⁴ To overcome the limitations of these methods and to find an alternate way of determining the accurate working length. As the technology advances, use of electronic apex locators (EALs) has more among dentists owing to increased accuracy and reduced exposure to radiation.⁵ EALs currently are being used to determine the working length as an important adjunct to radiography.

When compared with radiography, the new apex locators determine not only the location of apical foramen but also the apical constrictor.^{6,7} Root ZX apex locator from the third generation of apex locators simultaneously measures the impedances of two different frequencies (0.8 and 4 KHz)⁸ and provides apex location based on the resulting quotient. EAL makes it possible to measure length with high precision.⁶ According to the manufacturer; Root ZX mini apex locator and Root ZX apex locator have been built using the same technology.⁹

Despite the fact that using new EALs is the most accurate measurement method, there are always concerns about the various factors that may affect their accuracy.

Many studies have examined the effects of various factors on the accuracy of EALs such as different irrigants, bleeding, preflaring, and file size. In addition, electronic apex locators help to reduce the treatment time and radiation dose, which may be higher with conventional radiographic measurements. (Pascon, 2009).

Cell phones are most important part of our lives. In 2014, there is around 6.9 billion subscriptions available globally. Mobile phones works on principle of communicating and transmitting radio waves through a network of fixed antennas called base stations. The Radiofrequency waves are electromagnetic fields, and unlike ionizing radiation such as X-rays or gamma rays, can neither break chemical bonds nor cause ionization in the human body. Radiofrequency waves can generate an Electromagnetic interference (EMI), also called radio-frequency interference (RFI) and it affect the conduction circuit established by electronic apex locator. This disturbance may degrade the performance of the circuit or even stop it from functioning. Tang et al studied on interfering capability of 2G and 3G mobile systems on medical equipment's and showed that medical equipment's were more sensitive to 2G systems than 3G systems. (Kti-Tang, 2009)

Thus the present study was aimed to evaluate the effect of cell phone radiation on working length determination through electronic apex locators, in-vivo.

Aim: The purpose of this study is to evaluate the interference of smart phone (Iphone 6s plus) during working length determination on electronic apex locators (Root ZX mini and Raypex 6) function in vitro.

Objectives:

To evaluate the interference of iphone 6s plus on Root zx mini

To evaluate the interference of iphone 6s plus on Raypex 6

LITERATURE REVIEW

- Kim E, Lee S J(2003) conducted study on apex locators and stated that the electronic apex locator (EAL) machine has attracted a great deal of attention because it operates on the basis of the electrical impedance rather than by a visual inspection. The EAL is one of the breakthroughs that brought electronic science into the traditionally empirical endodontic practice. EALs are particularly useful when the apical portion of the canal system is obscured by certain anatomic structures, such as impacted teeth, tori, the zygomatic arch, excessive bone density, overlapping roots, or shallow palatal vaults. Indeed, EALs currently are being used to determine the working length as an important adjunct to radiography. EALs help to reduce the treatment time and the radiation dose.
- Gordon MPJ, Chandler NP.(2004) conducted study on apex locators. Modern electronic apex locators can determine this position with accuracies of greater than 90% but still have some limitations. Knowledge of apical anatomy, prudent use of radiographs and the correct use of an electronic apex locator will assist practitioners to achieve predictable results.
- Lawentschuk N, Boltan M D (2004) did study on mobile phone interference on medical equipment and its clinical relevance and concluded that all type of studies recommended some type of restriction of mobile phone use in hospitals, with use greater than 1 m from equipment and restriction in clinical areas being the most common.
- Francis J, Niehaus M (2006) conducted study on Interference between Cellular Telephones and Implantable Rhythm Devices: A Review on Recent Papers and concluded that Cellular phones are likely to interfere with implantable

rhythm devices if operated in close proximity or during programming of the device. Patients with implanted devices can safely use cellular phones if they are not carried close to the implanted devices or operated near them. Carrying the cellular phones in the belt position, receiving calls in the ear opposite to the side of the implanted device and keeping the phone as far away as possible while dialing can be considered a safe practice. Interrogation of the devices should take place exclusively in areas where utilization of cellular phones is strictly prohibited. Studies on pacemakers published in the current decade have shown much lesser rates of interference, possibly due to improvement in device technology.

- Morita J. Apex locator Root ZX Mini Operation Instructions, Operation. J. Morita Mfg. Corp; 2011. p. 26.
- Hurstel J et al (2015) conducted study on cell phones affect establishing electronic working length and concluded that reliability and stability of EALs were not influenced when placed in direct contact with a smart phone or GSM phone .patient or dentist may keep their cell phone on in treatment room during an endodontic therapy without disturbing EWL determination.
- Sindhu p et al (2016) conducted study on evaluation of interference of cellular phones on electronics apex locators: an in vitro study and concluded that WL determination by apex locators is not influenced by presence of cellular phones.
- Silva et al (2016) did study on electromagnetic interference of smartphones on apex locators: An in vivo study and concluded that mobile phones used in the present study did not affect accuracy of EWL measurements in vivo.
- Devi S Lekshmy et al (2016) did study on A comparative clinical study on the correlation of working length determined using three different electronic apex locators with radiographic working length: An in vivo study and resulted that Maximum correlation of readings with the radiographic length was shown by Root ZX followed by Apex ID and then by iPex.
- Shafieibavani M, Iranmanesh P, Iranmanesh F.(2016) did study on Evaluating electromagnetic interference of communication devices with root ZX mini apex locator and concluded that EMWs of 2G and 3G not causes malfunctions of the root zx mini apex locators except conversation with 2G at the direct contact.
- Jain A S, Asrani H, Singhal AC, Asrani A, Deshmukh P, Jain D(2017) conducted study on evaluation of the interference of smart phone (Iphone 5s) during working length determination on electronic apex locators (Root ZX and NSK ipex II) function in Do mobile phones cause interference on electronic apex locators? An in vitro study and concluded that Electronic apex locators tested did not cause inhibition or interfere with mobile phones.
- Gohil UK, Parekh VV, Kinariwala N, Oza KM, Somani MC(2017) Can active signals of cellphone interfere with electronic working length determination of a root canal in a dental clinic? An in vivo study. And concluded that cellphones do not interfere with the EWL determination
- Dr. Madhureema De Sarkar, Dr. Kundabala M., Dr. Neeta Shetty(2018) conducted study on Effect of cell phone radiation on electronic apex locator and concluded that Cell phones radiation interferes with the working length determination of electronic apex locators when placed next to it. Therefore it is advised to keep all cell phones in standby mode during root canal treatment especially when electronic dental equipments are in use.

MATERIALS & METHODS

Forty patients requiring root canal treatment were selected from the Conservative Dentistry & Endodontics Department of Narsinhbhai Patel Dental College, Visnagar. The entire procedure was explained to the patient. Written informed consent was obtained from the patients. Adequate field disinfection was performed. Local anesthesia was given in case of vital teeth. Occlusal or incisal grinding was done to obtain a stable reference point. After adequate access opening and rubber dam isolation, pulp was extirpated using no. 10 K-file and using 2.5% sodium hypochlorite solution. Working length determination was done with no. 15 K-file using Endobloc.

Two EALs were used in the study:

1. Raypex 6
2. Root ZX mini (J. Morita Mfg. Corp., Kyoto, Japan).

cellphone that was used to evaluate EMI: 1. iPhone 6s (Apple, manufactured in California)

Experimental setting The whole experiment was carried out in a closed room (9 feet × 9 feet). Working length was measured using no. 15 K-file and Endobloc under the following conditions for each EAL:

- 1: No cell phone present within 2 meter radius of the dental chair (including patient's mobile phone)
- 2: cell phone placed next to EAL with WiFi and bluetooth activated
- 3: cell phone placed next to EAL in safe mode.
- 4: cell phone placed next to EAL activated by ringing.

Inclusion Criteria:

1. Permanent teeth with mature root apex
2. Single rooted teeth with single root canal.
3. Patient age 18-78

Exclusion Criteria:

1. Periapical cyst
2. Open apex

3. Root resorption
4. Teeth with metallic restorations
5. Perforations
6. Fractured crown and root
7. Calcified tooth
8. Patients with cardiac pacemakers

Methodology:

40 patients with single rooted having Type I internal anatomy with mature apex indicated for root canal treatment of were included in the study. Patients with cardiac pacemakers, perforations, fractures of root, cases of immature apex, root resorption, haemorrhage and swelling were excluded from the study. Pre-operative Intra Oral Periapical (IOPA) radiograph was taken prior to access opening. Access cavity preparation was done after securing local anaesthesia, under rubber dam. After extirpation of pulp, working length radiograph was taken with 20 size K-file (3M ESPE, Denstply) using modified Ingle's technique. Discrepancies within 0.5mm to 1mm were noted and evaluated. It was then confirmed using electronic apex locator and adjusted till the reading in the display showed "0". Discrepancies from radiographic working length were noted. Working length was then determined with cell phone placed next to it under four conditions and a set of four readings recorded for every patient:

To determine the stability of EWL readings, the following scores were used:

- Score 1: Immediate and good signal strength with an audible and visible signal of 5 s and no problems determining the EWL
- Score 2: Slight instability with minor difficulties to determine the EWL (an audible and visible signal of 5 s was obtained but only after two attempts)
- Score 3: Major difficulties or impossible to determine the working length after three attempts.



Figure 1-Materials used in study

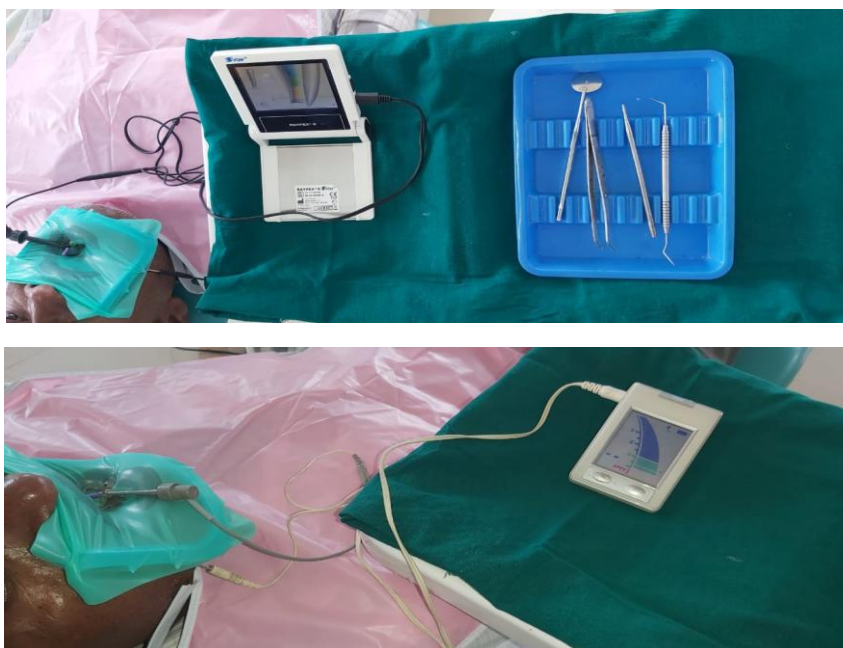


Figure 2-No cell phone present within 2 meter radius of the dental chair(including patient's mobile phone).



Figure 3- cell phone placed next to EAL with WiFi and bluetooth activated.



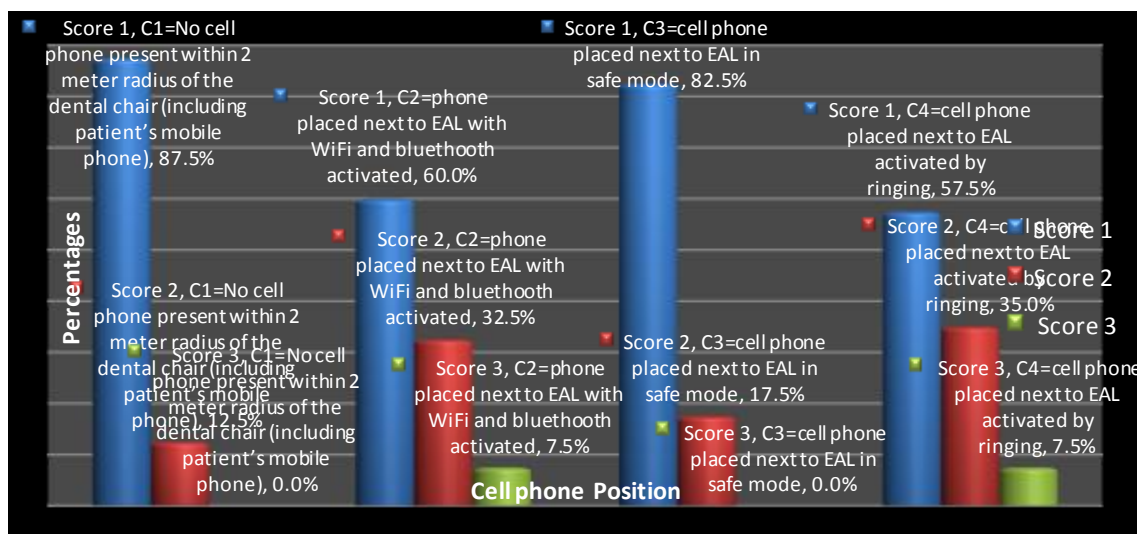
figure 4- cell phones placed next to EAL in safe mode.



figure 5-cellphone placed next to EAL activated by ringing

Statistical Analysis: The data were statistically analyzed using one-way ANOVA and paired t-test at 0.05 level of significance.

RESULT



Scores	ROOTZX MINI Groups	RAYPEX6 Groups	Total
SCORE 1= Immediate and good signal strength with an audible and visible signal of 5 s and no problems determining the EWL	34 (85)	35 (87.5)	69 (86.2)
SCORE2=Slight instability with minor difficulties to determine the EWL (an audible and visible signal of 5 s was obtained but only after two attempts)	6 (15)	5 (12.5)	11 (13.8)
SCORE 3=Major difficulties or impossible to determine the working length after three attempts.	0 (0)	0 (0)	0 (0)
Total	40	40	80
P Value	0.745 NS		

Statistically, no significant difference was present between ROOTZX MINI Group and RAYPEX6 Group with all four conditions.

DISCUSSION

The electronic apex locator (EAL) machine has its own benefit as it works on the basis of the electrical impedance rather than by a visual inspection. The EAL is one of the most useful electronic devices into the traditionally empirical endodontic practice.

Root canal therapy is an important part of dental practice. Moreover, the success of root canal treatment depends on various factors among which accurate working length determination plays a vital role. EAL which is a useful adjunct in root canal therapy to determine the working length helps in reducing chair time and radiation dose to the patient. The EAL is more reliable than digital radiography or cone beam computed tomography. Here, another factor termed as EMI also affect the working length determination is checked for

its interference. The external sources which generate EMI that affects an electrical circuit by electromagnetic induction, electromagnetic conduction, or electrostatic coupling. It is reported that electromagnetic radiation emitted from devices such as cellphones, iPods, and dental devices such as electric pulp testers, electrosurgery units, and ultrasonic scalers can interfere with the function of cardiac pacemakers, implanted in the patients.

Many Studies have reported that mobilephones can interfere with the function of pacemaker and this depends on the distance between the pacemaker and electronic device, power output of the electronic device.

Dentists, dental surgery assistants, and patients often use cellphones in proximity to dental devices. The technical support documents of EALs reported that cellphone, transceivers, remote controls, and all other devices which transmit electromagnetic waves should be turned off while using apex locators. There is a very

limited evidence that can conclude whether cellphones can be used in dental clinic and whether these devices can have any effect on EWL determination. This in vivo study has been performed to evaluate EMI of cellphones on EWL determination.

This study concluded that the use of cellphone at a distance of 2 meter radius from the EAL does not influence the readings of EALs. Thus, cellphones can be used in a dental clinic during root canal therapy without the risk of EMI between cellphone and EAL. These results are in accordance with two in vitro studies to evaluate interference of cellphones on EWL determination by Hurstel et al. and Sidhu et al. One study by Justine Hurstel and HerveTassery said that the effect of cell phones on establishing electronic working length and found out that neither the cell phone type nor the Electronic Apex Locator affected the measurements.

Single rooted teeth were selected in this study to prevent any interference of anatomical variations of multiple canals in working length estimation. Earlier studies have shown that there was no significant difference regarding EWL measurements between Raypex 6 and dual frequency Root ZX. This was confirmed by performing paired t-test in our study. Hence, Root ZX mini, a third-generation EAL a dual frequency device of 0.4 and 8 kHz, was selected for the study. iPhone 6s, a recent smartphone which has a more frequency of bands than most other mobilephones, which represents the group of cellphone working at a frequency of 900–1800 MHz were used to evaluate interference. As the distance between two electronic devices can influence EMI, 2 feet distance was kept in this study to simulate the exact clinical scenario of a dentist/dental hygienist talking on a cellphone. As the wave emission is intense during calling mode of a cellphone, calling mode was used in the study to maximize the chances of detecting EMI.

This study showed that there were no obvious signs of EMI between cell phones and EALs under all conditions. The

2 EALs used in this study worked correctly with good reliability and stability even in physical contact with a cell phone in standby or calling mode. Therefore, it was concluded that the presence of a cellphone in a dental office did not statistically influence the EWL measurements during root canal therapy. There is no noise of interference between the 2 devices was detected. Finally, the accuracy of the 2EALs was comparable in this vivo study.

The results of this in vivo study showed that there is no direct correlation between cellular phone use and EWL determination in dental clinic. In all the four experimental conditions the EAL showed good reliability and stability during treatment. This study concluded that presence of mobilephone in close proximity or at a distance from the EAL did not affect working length determination. Thus, mobilephones can be used in a dental clinic during root canal therapy without any risk of EMI between cellular phone and EAL.

CONCLUSION

From the results of the present in vivo study, it may be concluded that cellphones can be used safely in a dental operator without the fear of interference of EMI on EWL. The tested EAL does not interfere with smartphone. In dental clinics during electronic WL determination, mobile phones can be used without the phobia of causing electromagnetic interference. Further, in vitro and in vivo studies with different parameters may be beneficial to confirm the results of the present study.

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