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The effect of Wi-Fi signals on the measurement accuracy of electronic apex locator during root canal therapy

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Abstract

Background: The using of devices that emitted electromagnetic radiation has been limited in many healthcare centers to prevent interference with medical devices. The purpose of this in vitro study was to evaluate the effect of Wi-Fi Router (Tenda FH456) on working length determination using electronic apex locator (NSK-iPex II) in the presence of network connection with tablet (GT-N800) or not.

Materials and methods: Twenty-five intact teeth with a single root were sectioned at the cementoenamel junction. Visually, roots were examined under stereomicroscope (X20) and the working length was determined using a size 15 K-file. The effect of Tenda Wi-Fi router on accuracy of electronic working length measurement of electronic apex locator (iPex II) was determined in this study in closed room under 5 conditions (without router and tablet, with router in different distances 1 meter and 3 meters from electronic apex locator, with router and connected with tablet in different distances 1 meter and 3 meters from electronic apex locator). The electronic working length was measured 3 times per canal under each condition. The data were compared using analysis of variance.

Results: The mean of working length measured under microscope was (13.30), and the mean of working length by electronic apex locator was (13.14) while the mean values of working length in different conditions was fixed (13.12). Analysis of variance test (ANOVA) showed non-significant difference among working length measurements in different conditions (P-value ≥ 0.05).

Conclusion: Within the limitations of the present study, stability and reliability of iPex II apex locator in measurement of electronic working length where not influenced when placed in (1M, 3M) from Wi-Fi router and active Tablet (connected to network by Wi-Fi and streaming online videos). During root canal therapy, active Tablet can be used in the dental operatory without the fear of causing electromagnetic interference in electronic working length determination.

Keywords: Working length, electronic apex locator, Wi-Fi, electromagnetic interference.

Introduction

The success rate of root canal treatment depends on various factors among which correct working length (WL) estimation [1, 2]. Establishing the WL at the apical constriction is considered ideal for endodontic treatment [3]. The apical constriction or minor apical diameter represent the narrowest apical part of the root canal with an assortment of morphological variations that make its identification not to be predicted [1, 4].

Electronic devices for WL determination have gained popularity and eliminate many of the problems associated with radiographic measurements [2, 5-7]. Different models of EALs have been generated [8]. The simplest devices measure resistance, while others measure impedance using either high frequency, two frequencies, or multiple frequencies. Various factors such as right application, presence of (irrigants, pulp tissue and pus) inside canal can effect on the accuracy of EALs [8-10]. Moreover, studies have shown that EALs provide accurate WL estimation when compared with the radiographic method [6, 11]. The endodontist can utilized from EAL in reducing time and radiation dose to which the patient is subjected [2].

A multitude of devices that emit electromagnetic radiation (EMR) are used in industrial, scientific, medical, military, and domestic applications. The level of EMR in our environment has increased manifold due to a large-scale expansion of communication networks behind such technologies as mobile phones. [12, 13].

Wi-Fi Alliance (Wi-Fi) is a prevalent technology that allows electronic devices to connect to wireless local area network (WLAN) and exchange data wirelessly, mainly using the 2.4GHz and 5GHz frequency bands. However, the term "Wi-Fi" is used in general English as a synonym for "[Wireless Fidelity]" [14].

Generally, when the cellular telephones are in nearby to the medical devices, the electromagnetic interference (EMI) can occur between phones and medical devices [15]. The rate of incidences of EMI can be increased in newer generation of mobiles that can access the Internet as well as exchange information wirelessly [16]. Regardless of the improved magnetic shielding of critical care and life support equipment, there is a possibility that EMI can cause equipment to display an incorrect value [17].

Moreover, dentists and assistances often keep their own cell phones, tablets, laptops connected to network with Wi-Fi signals of router during using EAL for measurement of WL of canals. However, to the best of our knowledge and after searching in past researches, there is no previous publication discussing the possibility of EMI between Wi-Fi router and EAL. So, the purpose of this vitro study aimed to evaluate the reliability of iPex II EAL when placed in different distances from switch on Tenda Wi-Fi router in presence of connection with Tab to network or not.

Materials and methods

Twenty-five human mandibular premolars (1 canal/tooth) without fracture or carious lesions were thoroughly cleaned before the experiment then observed under magnification (x20) using stereomicroscope (Meiji Techno, Japan), Figure (1), to check for the existence of maturity of apex, single apical foramen. The roots with resorption, immature apex, and any

other anatomic irregularities were excluded. The teeth were decoronated at the cemento-enamel junction (CEJ) and stored in distilled water until usage to maintain their hydration.

The model of EAL that used in this study was iPex II (NSK, Japan): a fourth generation EAL. It based on a multi-frequency principle which automatically selects the best possible combination of frequency in line with the canal condition by simultaneously measuring capacitance and resistance to determine the position of the file tip inside canal [18, 19].

Tenda FH456 router was used in this study (China) which work on the medium and large size house, Figure (2). It gives stable and wide range Wi-Fi signal up to 300Mbps and whole-home coverage. It operates on 2.4GHz frequency band.

Samsung Galaxy Note 10.1 Tab (GT-N800) (Vietnam) multiband android smart phone, Figure (3), and can operate on 2.4GHz frequency band was used in this study.

After identifying the root canal orifice, the pulp tissues were carefully removed using barbed broach and size 8 K-file. Then, a glide path was prepared with a precurved size 10 K-file, and canal patency was confirmed; roots with canal obstructions (e.g. calcifications) were excluded.

After rinsing with 2ml of NaOCl at 2.5%, a size 15 K-file fitted with a rubber stop was inserted until visible at the apical foramen using a Meiji Techno stereomicroscope (x20). The actual WL was determined to be 0.5mm coronal to the major apical foramen [20, 21]. After withdrawing the size 15 K-file from the canal, its length was measured with an endodontic ruler. This experiment was repeated 3 times per root، and the mean values were calculated and kept blinded for the remainder of the study.

The EWL was established using an experimental design which was described and used by **Hurstel et al.** [22]. Two holes were made in the cap of a plastic container, and the root was inserted in one of hole while the lip clip of the EAL was inserted through second one, (Figure 4). The plastic container was filled with 0.9% NaCl solution (normal saline), and the apical and middle thirds of the root were inserted into it. The root canal was irrigated with 2.5% NaOCl, and EWL was calculated. The file tip was inserted into the root canal, and the file clip was attached. The file was pushed beyond the 0 reading on the EAL display and withdrawn slightly until the 0.5 reading was appeared, this reading was confirmed by audible signal emitted from the EAL, then the file stop was adjusted, and this length was recorded as EWL.

For each canal of 25 specimens, the EWL was performed under 5 different conditions using Tenda router, iPex II EAL and Samsung Galaxy Note 10.1:

1. No Wi-Fi of router and tablet in the room (control group).
2. Presence of router with Wi-Fi switch on located 1M from EAL to show the chance of EMI.
3. Presence of router with Wi-Fi switch on located 3M from EAL under the same conditions in no.2.
4. Presence of router with Wi-Fi switch on located 1M from EAL and presence of Wi-Fi connection to network between Tablet 10.1 and router to maximize the chance of EMI. The active tablet was switch on and used to watch online video during the measurement with EAL.
5. Presence of router with Wi-Fi switch on located 3M from EAL and presence of Wi-Fi connection to network between Tablet 10.1 and router under the same conditions in no.4.

Bluetooth and call settings were inactivated for Tablet to prevent any electronic interference. The experiment was carried out in a closed room to prevent interference from other phones or any other wireless devices that work on Wi-Fi. Three EWL measurements were recorded per canal and mean values were calculated for each condition for EAL.

Data was analyzed using SPSS® software. Both descriptive statistics (Mean, Standard deviation), analysis of variance test (ANOVA) with least significant differences (LSD) were used in order to analyze and assess the results of the study.

Results

According to the results of this study, the mean of WL measured under microscope was (13.30), and the mean value of WL by EAL was (13.14) while the mean values of WL in different conditions was fixed (13.12), (Table 1).

The (ANOVA) test showed non-significant (NS) difference among WL measurements in different conditions (P-value ≥ 0.05), (Table 2).

The (LSD) test showed that there were (NS) differences among WL measurements in different conditions (Table 3).

Discussion

Electromagnetic interference occurs when one or more electronic devices adversely interfere with the operation of another electronic device. Any device that transferring radio frequency, like mobile or laptop computer which connected to a network wirelessly, has the possibility to electronically interfere with the work of another electromagnetic device because of the physics governing radio waves as electrons transfer, they make electromagnetic waves that diffuse through free space and potentially interact with other. In healthcare facilities, wireless EMI occurs when wireless devices interfere with medical equipment, potentially causing equipment malfunction [23-25].

Wireless devices are commonly used in all areas of life [26]. There was suggested rules that determine a minimum separation distance between wireless devices and sensitive medical equipment. The increasing the minimum distance between wireless devices and medical equipment to at least one meter (three feet), the risk of EMI can be reduced significantly for most wireless devices, especially smart cell phones [16, 27-30]. Also, handheld radios are not allowed within 10 feet (approximately 3M) of any medical device [27]. So, different distances (1M, 3M) were used in this study.

In this study, the glide path was confirmed because the preflaring of root canals before measurement with EAL can increase the precision of WL determination [31]. The normal saline was used because this material has properties of electro-conductive materials [32], so the EAL can give accurate reading. Also, each root was irrigated with 2.5% NaOCl, and EWL was calculated. The NaOCl can be safely used with EAL in WL determination [33].

According to the results of this study, there was minimal change in measurement reading of WL in the presence of Wi-Fi signals in different distances (1M, 3M) in the presence of Tablet or not. This change was not statistically significant and may be not effective clinically. This result was agreed with **Hurstel et al.** [22] in **2015** and **Sidhu et al.** [34] in spite of those authors in two researches used others types of EALs and cellular phones but they don't used Wi-Fi router. This result may be due to that Wi-Fi signals

have low power, so that the probability of occurrence of EMI was less [30]. The cause of minimum power output can be related to the Institutions that manufactures these electronic devices to meet the regulations that allowed in each country.

Under all the experimental conditions the iPex II EAL showed good reliability and stability where the difference between two WL mean values (WL measured under microscope and WL measured by EAL) was 0.2 which was considered a non-significant value. This result was agreed with **Vasconcelos et al.** [35].

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Figure (1): Meiji Techno stereomicroscope.

Figure (2): Tenda FH456 router.

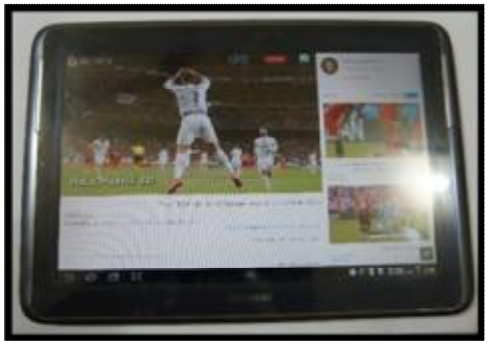

Figure (3): Active GT-N800 Tab that connected to network by Wi-Fi and watching online video.

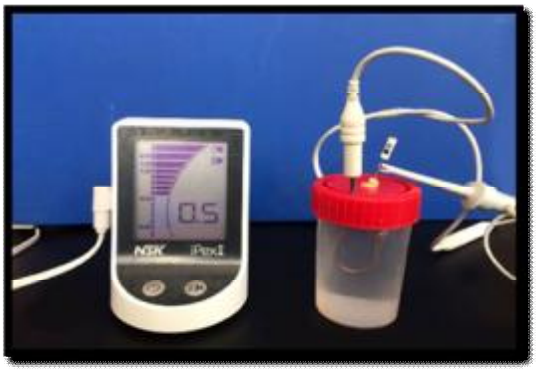

Figure (4): Experimental model and iPex II electronic apex locator.

Table 1: Descriptive statistical results of WL measurements.

Working length	Mean	SD
Under microscope	13.30	0.38
Using Apex Locator	13.14	0.50
Using Apex Locator with Wi-Fi in 1M distance	13.12	0.49
Using Apex Locator with Wi-Fi in 3M distance	13.12	0.49
Using Apex Locator with Wi-Fi in 1M distance and Tablet in 1M distance	13.12	0.49
Using Apex Locator with Wi-Fi in 1M distance and Tablet in 3M distance	13.12	0.49

Table 2: ANOVA test of WL measurements.

ANOVA	SS	DF	MS	F-test	P-value	Sig.
Among groups	0.62	5	0.12	0.53	0.747	NS
Within groups	33.55	144	0.23			
Total	34.18	149				

P ≥ 0.05 Non-Significant (NS) P < 0.05 Significant (S)* P < 0.01 High Significant (HS) * *

Table 3: LSD test to compare of WL measurements among groups.

WL measurements		MD	SE	P-value	Sig.
Under microscope	Apex Locator	0.16	0.13	0.243	NS
	Apex Locator with Wi-Fi in 1M	0.17	0.13	0.199	NS
	Apex Locator with Wi-Fi in 3M	0.17	0.13	0.199	NS
	Apex Locator with Wi-Fi and Tablet in 1M	0.17	0.13	0.199	NS
	Apex Locator with Wi-Fi and Tablet in 3M	0.17	0.13	0.199	NS
Apex Locator	Apex Locator with Wi-Fi in 1M	0.01	0.13	0.907	NS
	Apex Locator with Wi-Fi in 3M	0.01	0.13	0.907	NS
	Apex Locator with Wi-Fi and Tablet in 1M	0.01	0.13	0.907	NS
	Apex Locator with Wi-Fi and Tablet in 3M	0.01	0.13	0.907	NS
Apex Locator with Wi-Fi in 1M	Apex Locator with Wi-Fi in 3M	0.00	0.13	1.000	NS
	Apex Locator with Wi-Fi and Tablet in 1M	0.00	0.13	1.000	NS
	Apex Locator with Wi-Fi and Tablet in 3M	0.00	0.13	1.000	NS
Apex Locator with Wi-Fi in 3M	Apex Locator with Wi-Fi and Tablet in 1M	0.00	0.13	1.000	NS
	Apex Locator with Wi-Fi and Tablet in 3M	0.00	0.13	1.000	NS
Apex Locator with Wi-Fi and Tablet in 1M	Apex Locator with Wi-Fi and Tablet in 3M	0.00	0.13	1.000	NS

P ≥ 0.05 Non-Significant (NS) P < 0.05 Significant (S)* P < 0.01 High Significant (HS) * *