ORIGINAL ARTICLE

Assessment of Smartphone Interference with Electronic Apex Locator in Working Length Determination: A Clinical Study

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Abstract

Aim: The aim of this clinical study was to determine the reliability of the electronic apex locator (EAL), in the presence and absence of a smartphone during working length determination.

Materials and methods: Thirty patients requiring root canal treatment were included in this study. The working length was measured using DentaPortZX, a third-generation apex locator. Two smartphones were used in this study, an Apple iPhone 6s and a Samsung S7. For each canal, electronic working length was determined using a no 15 K-file under three different criteria: no smartphone was placed next to the EAL; an iPhone 6s with activated Wi-Fi, Bluetooth, and calling mode was placed next to the EAL; and Samsung S7 with activated Wi-Fi, Bluetooth, and calling mode was placed next to the EAL during the working length determination. Working length was determined thrice for each canal following all the three criteria and an average of the three values was considered as the final value for each criteria.

Results: It was possible to determine the working length using an EAL under all three experimental conditions. The results of the nonparametric test, Kruskal-Wallis ANOVA, was found to be nonsignificant. No significant difference ($p = 0.991$) was found for electronic working length measurement in the presence or absence of smartphones used in this clinical study.

Conclusion: The results of this clinical study conclude that smartphones can be used without the fear of electromagnetic radiation interference to the EAL during working length determination.

Keywords: Electronic apex locators, Smartphones, Working length determination.

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The success of the root canal therapy depends upon debridement of the root canal system by complete removal of the pulp tissue, necrotic materials, and microorganisms. This endodontic success can be achieved by accurate determination of working length.[1,2] Overestimation and underestimation of working length can influence the outcome of the root canal therapy.[3] Working length is defined as the distance from the coronal reference point to the point at which the canal preparation and obturation must terminate.[4] Every effort must be made to determine the working length as precisely as possible.[5]

In teeth, which are indicated for root canal therapy, the accurate determination of working length is a critical step for the success of treatment. Anatomically, the apical constriction, also called the minor apical diameter (Kuttler, 1955), is a location for working length determination. Thus, the apical preparation of the root canal therapy must end at this natural barrier.[6] It is estimated that the minor apical foramen on an average is located 0.5–1.0 mm short of the radiographic apex.[7,8] Individualistic variation in this location can cause overfilling or underfilling of the root canal filling material.[9,10]

The electronic apex locator (EAL) acts as an aid in determining the working length accurately and precisely.[11] According to Kim et al., it is always better to combine the radiographic and electronic method together for accurate results.[12] Electronic apex locators help reduce the treatment time and the radiation dose, while the radiographic method aids in diagnosing the root canal anatomy.[13,14]

The EAL was an innovation proposed by Custer to determine the canal terminus accurately.[15] It is based on the principle that the electrical conductivity of the PDL is greater than conductivity inside the root canal system under a dry field.[16] This leads to the development of the electronic root canal length measurement device (ERCLMD).[17,18] DentaPort ZX (J. Morita, Japan) is a third-generation apex locator, which determines the position of the minor diameter by simultaneous measurement of impedance at two different frequencies (8 and 0.4 kHz).

The amount of electromagnetic radiation emitted from a digital smartphone is estimated to be low, which is around 42 V/m at 0.1 m dropping to below 7 V/m at 1 m in the standby mode. So, when a medical equipment is used in the vicinity of a smartphone, two things have to be taken into consideration; one is the amount of electromagnetic radiation they produce and the other is the safe distance at which the equipment should be placed.[19,20] The EAL is contraindicated in patients with pacemaker due to electromagnetic interference.[21–23] Likewise, one of the major concerns regarding an EAL is the inaccuracy caused by the electromagnetic interference due to the usage of smartphones in the ambience.[24] To prevent the electromagnetic interference from a smartphone, various measures like using it in nonpatient area, restriction in clinical area, and using it at a distance of more than 1 m from the medical equipment are preferred.[25,26]

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It has been proved through recent *in vitro* studies that there is no interference in the accuracy of measuring working length through EAL in direct contact with a smartphone.[26,27] The purpose of this clinical study was to determine the reliability of EAL DentaPort ZX in close proximity with two smartphones (iPhone 6s and Samsung S7) and the absence of a smartphone in the experimental site.

Materials and Methods

Thirty patients requiring root canal therapy were selected for this study. The entire procedure was explained to the patient. A written informed consent was obtained from the patients. Preoperative periapical radiographs were taken. The permanent teeth with mature root apex, single rooted teeth with single root canal, and patients aged 18–60 were included in the study. The teeth with periapical cyst, open apex, root resorption, perforations, fractured root, calcified tooth, and patients with cardiac pacemakers were excluded from the study.

After achieving adequate field of disinfection, local anesthesia was administered. Occlusal grinding was done to obtain a stable reference point. Access opening was performed and pulp was extirpated using a no. 10 K-file under rubber dam isolation. The access cavity was irrigated with 2.5% sodium hypochlorite solution (Fig. 1).

The working length for the teeth used in the study was determined by a single operator. The DentaPort ZX was used according to the manufacturer's instructions. The lip clip was attached to the patient's lip and a 15 K-file was connected to the electrode of the apex locators. The file insertion ceased when the meter flashed, and an audible signal showed that the foramen had been reached. The same procedure was carried out during the entire clinical scenario for the electronic working length determination.

- Working length determination using EALs in the absence of a smartphone at the operator's area (Fig. 2)
- Working length determination using an EAL in the presence of a smartphone, an iPhone 6s, with activated Wi-Fi, Bluetooth, and calling mode (Fig. 3)
- Working length determination using EALs in the presence of a smartphone, Samsung S7, with activated Wi-Fi, Bluetooth, and calling mode (Fig. 4)

The whole experiment was carried out in a closed room around 10 × 10 feet. The smartphone and the EAL were closely placed at the time of working length determination. Working length was determined thrice for each canal under each clinical set-up and an average of the three values was considered as the final value. Data obtained were entered in MS Excel sheet and analyzed using SPSS

Fig. 1: Armamentarium

Fig. 2: Working length determination without smartphone

Fig. 3: Working length determination with iPhone 6s

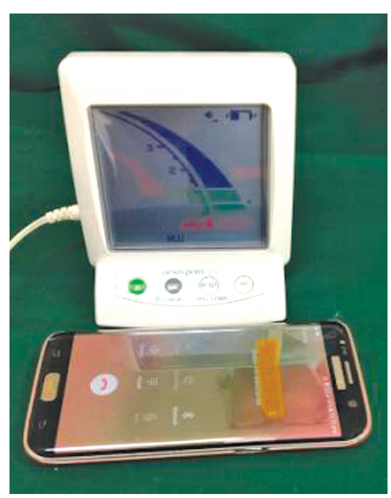

Fig. 4: Working length determination with Samsung S7

Table 1: Descriptive statistics

Group	*Mean*	*Standard deviation*	*Mean rank*	*p value*
EAL	19.5	1.19	45.97	0.991*
EAL + S7	19.43	1.07	45.45	
EAL + I6S	19.46	1.22	45.08	

*Kruskal-Wallis ANOVA

VERSION 20.0. The statistical data were found to follow nonnormal distribution and hence a nonparametric test, Kruskal-Wallis ANOVA, was used to test between groups.

Results

It was possible to determine the electronic working length under all three experimental conditions. The results of a nonparametric test, Kruskal-Wallis ANOVA, was found to be nonsignificant. No significant difference ($p = 0.991$) was found for electronic working length measurement in the presence or the absence of a smartphone used in this clinical study (Table 1).

Discussion

Working length determination is an integral part of the root canal therapy. Electronic apex locators are used to achieve this with enhanced reliability, stability, to lessen the treatment time and radiation exposure when compared to the conventional radiographic method of working length determination.[28] With increasing usage of smartphones in recent days, it was found that more than 3.50 billion people own a mobile phone. According to a worldwide survey in 2019, this accounts for about 45.12% of the world population.[29]

Hence, this clinical study was performed to assess the electromagnetic interference of a smartphone that was used in close proximity to the EAL during working length determination. Various technical data have stated that the electromagnetic interference of a smartphone causes inaccurate reading of EAL; thus, EAL should not be used in close proximity to a smartphone.[27] The results of the present study showed no variation in the presence or the absence of two smartphones when placed directly to the EAL (DentaPort ZX).

Sindhu et al. evaluated the effect of a smartphone (Samsung Galaxy Note Edge) on the working length determination of Propex II and Rootor, under two experimental conditions and concluded that the electronic working length measurements were not influenced by the presence of a smartphone and could be determined under all experimental conditions. Hurstel et al. in 2015 determined the effect of a smartphone (iPhone 5) in working length determination with EALs Root ZX module and Propex II and concluded that electromagnetic radiation from a smartphone does not cause any interference with electronic working length determination. Thereby, patients can keep their smartphones on the switch-on mode during root canal therapy. Emmanuel J. N. L. Silva et al. in 2016 determined the effect of two smartphones (iPhone 5S and Samsung Galaxy S5) on the reliability of two EALs (Novapex and Root ZX II) under two experimental conditions and concluded that mobile phones used in the study did not affect the accuracy of electronic working length determination *in vivo*. In this present study, the electronic working length was determined with a single EAL under three experimental conditions: no Smartphone was placed next to the EAL, an iPhone 6s with activated Wi-Fi, Bluetooth, and calling mode was placed next to the electronic apex, and a Samsung S7 with activated Wi-Fi, Bluetooth, and calling mode was placed next to the EAL during working length determination.

The study was carried in a closed clinical room of 10 × 10 feet where the smartphones were kept close to the EAL. The Wi-Fi, Bluetooth, and calling modes were activated to maximize the interference of electromagnetic waves. After proper recording and statistical analysis, it is found that there was no electromagnetic interference from the smartphones used during the electronic working length determination. The results of various other *in vivo* studies to determine the interference of electromagnetic waves with smartphone and electronic working length determination conclude that there was no interference in working length determination using the EALs. Hence, smartphones can be used in the vicinity of EAL during the working length determination. Furthermore, various clinical studies can be performed under different criteria to confirm the results of the present study.

Conclusion

The results of this clinical study conclude that smartphones can be used in the vicinity without the fear of electromagnetic radiation interference with the EAL during the working length determination.

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