EGYPTIAN
DENTAL JOURNAL

Vol. 64, 2827:2832, July, 2018

I.S.S.N 0070-9484

Fixed Prosthodontics, Dental materials, Conservative Dentistry and Endodontics

www.eda-egypt.org • Codex : 210/1807

INFLUENCE OF IRRIGANTS ON ACCURACY OF IPEX II AND DENTAPORT ZX IN WORKING LENGTH DETERMINATION

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ABSTRACT

Introduction: The aim of this study was to assess the accuracy of iPex II (NSK, Tochigi, Japan) and Dentaport ZX (Morita Co, Kyoto, Japan) electronic apex locators (EALs) in working length determination in dry condition and in the presence of the following irrigants: 0.9% saline solution (NaCl), 2.6% sodium hypochlorite (NaOCl), and 2% chlorhexidine (CHX).

Materials and methods: Fifteen extracted, maxillary first molars were used. The actual canal lengths (ALs) were determined. An alginate model was used to determine the electronic length using a size 15 K-file by each EAL in different conditions. Percentage of accuracy was calculated at ±0.5 mm, 1 mm and 1.5 mm tolerance level. Statistical analysis was performed using the Friedman and Wilcoxon signed rank tests at a significance level of $P < .05$.

Results: Results revealed a non-significant difference between the ALs and the electronic lengths (ELs) of both EALs among different canal conditions. Also a non-significant difference was shown between both EALs among different canal conditions.

Conclusions: Both EALs are shown to be accurate in WL determination among different canal conditions.

Key words: apex locator, iPex II, Dentaport ZX, irrigants, working length

INTRODUCTION

Working length (WL) determination during root canal treatment is a critical step[1, 2]. The WL is best defined as the distance from a coronal reference point to the point at which canal preparation and obturation should terminate[3]. Overestimation of the WL can cause damage to the periapical tissues delaying healing. On the other hand, underestimation will lead to insufficient cleaning of the root canal space prevent healing as well. Radiographic method for WL determination cannot locate the exact position of the apical constriction or major foramen[4–5]. Moreover, radiographic picture is only a two-dimensional projection of a three-dimensional object. Superimposition of structures might obscure identification of the radiographic apex. Electronic

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apex locators (EALs) are shown to be more accurate in WL estimation than radiographs [6].

In 1918, Custer first proposed electronic devices usage for WL determination [7]. In 1942, Suzuki developed the first EAL [8]. First generation EALs were resistance-based whereas second generation ones were impedance-based; both of which showed inaccuracy with electrolytes. Therefore , third-generation EALs, such as Root ZX (J Morita Corp, Tokyo, Japan) were then introduced using the ‘‘ratio’’ method. It measures the impedance values at two frequencies (8 KHz and 0.4 KHz) simultaneously and then calculates a quotient that expresses the position of the file tip in the canal [9]. Dentaport ZX is considered to be the gold standard against which newer EALs are evaluated [10]. iPex II (NSK, Tochigi, Japan) is claimed to be a fourth-generation apex locator that measures capacitance and resistance simultaneously.

In vitro or ex vivo models use electroconductive materials to simulate clinical conditions. Alginate, agar, saline, and gelatin have been shown to give predictable results when used with EALs [11]. Precision of electronic WL measurement depends on the EAL used and the type of irrigant [12].

To the best of our knowledge, no published data have evaluated the influence of different irrigants on the accuracy of the iPex II EAL. The purpose of this study was to assess the effect of different irrigants on the accuracy of iPex II and Dentaport ZX in WL determination in vitro.

MATERIALS AND METHODS:

Fifteen extracted, maxillary molars were selected. Roots with resorption, cracks, fractures, or immature apices were excluded. Calculus was removed with hand instrumentation and teeth were stored in saline (NaCl) (0.9%) till use.

Flattening of the occlusal surface was done using a diamond disc to provide a constant reference point for measurement. Palatal canals only were used for this study. Canal negotiation and instrumentation was done till size 15 K-file (Dentsply Maillefer, Ballaigues, Switzerland), and apical patency was checked with a size 10 K-file (Dentsply Maillefer). Then, the canals were irrigated with 2.5 mL 2.6% sodium hypochlorite (NaOCl).

The actual lengths (ALs) were determined by visualization of the file tip under a dental operating microscope (Leica, Leica Microsystems, China) with a magnification of 8X. The length was measured to the nearest 0.05 mm with a caliper.

Teeth were embedded in an alginate model. Resinous cast was filled with alginate impression material and teeth were immersed in it before setting. One lip clip was immersed in the alginate before setting and the file holder was attached to K-file# 15.

Electronic lengths (ELs) measurements were obtained immediately after alginate setting by each EAL according to the manufacturer’s recommendations in dry conditions and in the presence of 2.6% NaOCl, 0.9% NaCl, and 2% chlorhexidine using a size 15 K-file. Each canal was irrigated with distilled water and dried with paper points between measurements.

Accuracy percentage was calculated at ±0.5 mm, ±1 mm and ±1.5 mm tolerance level.

Statistical analysis

Statistical evaluation was performed using XLSTAT for Microsoft Excel (version 2018). Friedman and Wilcoxon signed rank tests were used to analyze the data. The level of significance was set at $P < .05$.

RESULTS

The mean and the standard deviation of the AL and the EL of both apex locators among different canal conditions are shown in Table 1. There was no significant difference shown among the different canal conditions using both EALs. Also a non-significant difference was shown between the EL and AL using both EALs among different irrigants. Although the Dentaport ZX appeared to be more accurate especially in the dry canal condition; yet, the difference was shown to be statistically non-significant.

Accuracy percentage within a tolerance of ±0.5 mm, ±1 mm, ±1.5 mm for both apex locators tested among different canal conditions are shown in tables 2-5 and figure 1.

TABLE (1) The mean and the standard deviation of the AL and EL of both apex locators among different canal conditions (mm)

	Dry	Sodium Hypochlorite	Saline	Chlorhexidine
Dentaport ZX	21.4±0.5732[a]	21.4±0.5732[a]	21.36±0.6114[a]	21.36±0.5498[a]
iPex II	21.33±0.5563[a]	21.33±0.5563[a]	21.133±0.6114[a]	21.33±0.5563[a]
Actual Length	21.4±0.5732[a]			

***** Mean values followed by same superscript letters in the same row or column are statistically non-significant ($P \leq 0.05$).*

TABLE (2) Accuracy percentage of Dentaport ZX and iPex II in dry condition within a tolerance of ±0.5 mm, ±1 mm, ±1.5 mm.

	0 mm	±0.5 mm	±1 mm	±1.5 mm	±2 mm
Dentaport ZX	100%	0%	0%	0%	0%
iPex II	86.60%	13.30%	0%	0%	0%

TABLE (3) Accuracy percentage of Dentaport ZX and iPex II using 2.6% sodium hypochlorite within a tolerance of ±0.5 mm, ±1 mm, ±1.5 mm.

	0 mm	±0.5 mm	±1 mm	±1.5 mm	±2 mm
Dentaport ZX	100%	0%	0%	0%	0%
iPex II	86.60%	13.30%	0%	0%	0%

TABLE (4) Accuracy percentage of Dentaport ZX and iPex II using 0.9% saline within a tolerance of ±0.5 mm, ±1 mm, ±1.5 mm.

	0 mm	±0.5 mm	±1 mm	±1.5 mm	±2 mm
Dentaport ZX	93.30%	6.60%	0%	0%	0%
iPex II	66.60%	26.60%	6.60%	0%	0%

TABLE (5) Accuracy percentage of Dentaport ZX and iPex II using 2% chlorhexidine within a tolerance of ±0.5 mm, ±1 mm, ±1.5 mm.

	0 mm	±0.5 mm	±1 mm	±1.5 mm	±2 mm
Dentaport ZX	93.30%	6.60%	0%	0%	0%
iPex II	86.60%	13.30%	0%	0%	0%

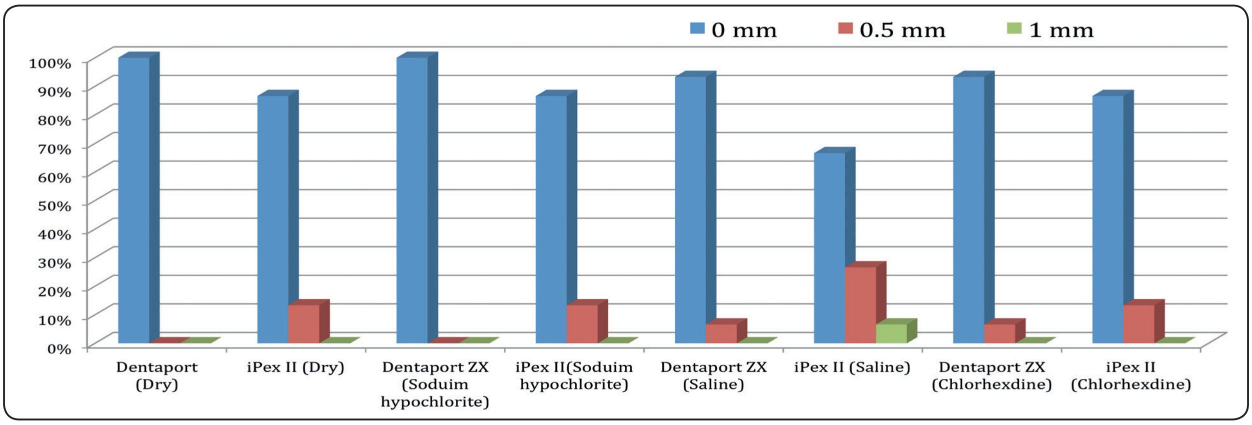

Fig. (1) Accuracy percentages of all groups at ±0.5-mm and 1 mm tolerance level.

DISCUSSION

Numerous in vitro and in vivo studies have been conducted to determine the accuracy of EALs. Most of the EALs showed a high-degree of accuracy in WL measurement[13,14]. The major foramen [13] or the minor foramen [15] is used in vitro studies as the apical reference point. Yet, the major foramen could be a more reproducible reference point for in vitro studies [16].

In the current study, an alginate model was used as previously described by Kaufman et al. [17]. Alginate has electrical impedance that imitates the human periodontium, can be used for in vitro assessments of EALs [18] and can also be used with any irrigation solution [19]. It is accurate, easy to use and reliable[19] as its construction required no special materials other than heat cured acrylic resin and alginate impression material. This model could provide service up to 24 hours without bias. The validity of this model for its application in research was tested, as accuracy studies using radiographs and SEM have been well documented [20]. Measurements were done immediately after setting of the alginate.

Results of an in vitro study may raise doubts about its clinical relevance. Some previous studies indicate that, even in fully controlled in vitro study conditions, there is some inconsistency in EAL measurements [21]. It should be emphasized that the results obtained in this in vitro study cannot be directly extrapolated to the clinical situation, but can provide an objective examination of a number of variables that are not practical to test clinically.

The literature shows conflicting results regarding the effect of irrigants on EALs. Results of the present study came in full agreement with those of Kaufman and Li in which the irrigants used did not affect the accuracy of different EALs tested [22, 23]. Marigo et al [24] found that the accuracy of the Dentaport ZX was not affected by sodium hypochlorite. Duran-Sindreu et al [25] also showed that sodium hypochlorite had no effect on the accuracy of the Root ZX and the iPex. Stöber et al. [26] also observed no significant differences between the iPex and Root ZX devices using 2.5% sodium hypochlorite. On the other hand, Venturi and Breschi [27] revealed unstable measurements for the Root ZX in dry canals. Kaufman et al [17] also showed the Root ZX to be more accurate in the presence of EDTA and saline than in dry canals. However, in our study, the Dentaport ZX and the iPex II were not affected by the canal condition.

Minor and major foramen morphology together with the location of the major foramen are three important factors influencing the accuracy of EALs

[27,28,29,30]. Stein et al. [28] reported that the accuracy of EALs depends to a great extent on the major foramen diameter. Others have observed that the accuracy of EALs varies depending on the minor foramen diameter [30, 31]. Therefore, the different results from different studies could be attributed partly to the nature of teeth used.

Tolerance of ±0.5 mm was used in many studies to assess EALs accuracy [32, 33, 34, 35]. Herrera and others used a more lax range of ±1.0 mm [31]. Results within these ranges are considered accurate and clinically acceptable. In our study, all the results fall in this range and thus are considered acceptable.

Comparison of the standard deviation is helpful for assessing reliability of EALs. If the EAL measurements are consistent, a low standard deviation is obtained. In our study, standard deviations were nearly equal for both EALs among all canal conditions.

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