Efficiency of an Integrated Apex Locator in Determining Working Length in Various Irrigating Solutions: An In Vivo Study

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Objective(s): The objective of this in vivo study was to compare and evaluate the accuracy of VDW Gold (VDW, Munich, Germany) integrated apex locator (IAL) and Root ZX Mini (J. Morita Corp., Kyoto, Japan) in two different irrigating solutions.

Materials and Methods: Forty patients who required extraction were included in the study. Following local anesthesia, access opening was performed under rubber dam isolation. Initial negotiation of canal was performed using size 10 K-Files (M-Access, Dentsply Maillefer, Ballaigues, Switzerland). Cervical preparation was carried out using Rotary ProTaper SX files (Dentsply Maillefer, Ballaigues, Switzerland) under copious irrigation with 3% sodium hypochlorite. Patients were divided into two groups of 20 each: Group I (NaOCl) and Group II (CHX). The working length (WL) was determined in triplicates for each tooth using Root ZX apex locator and with S1 ProTaper rotary file in continuous motion in case of VDW Gold IAL in the presence of 3% sodium hypochlorite and 2% chlorhexidine. Therapeutic extraction was performed and WL was determined using size 15 K-Files under 20× magnification.

Results: The paired sample independent t test showed that there was no significant difference between the Root ZX and VDW apex locator in determining the WL in NaOCl group (P = 0.234, 0.453 respectively) and CHX group (P = 0.085, 0.087) when compared with actual working length.

Conclusion: Both the apex locators were equally effective in determining WL at 0.5 mm from the apex in presence of irrigating solutions, that is, NaOCl and chlorhexidine.

Keywords: Chlorhexidine, electronic apex locators, integrated apex locator, irrigating solutions, minor foramen, sodium hypochlorite, working length

For a successful endodontic therapy, the ability to precisely measure the working length (WL) plays a vital role. The steps of root canal therapy, that is, biomechanical preparation and obturation, cannot be accomplished unless accurate length of the tooth is measured. Failure to establish proper WL leads to the damage of periradicular tissues and various procedural errors. The most popular and commonly used method of WL determination is the radiographic method. However, distortion, shortening and elongation, and interpretation variability are the common drawbacks. Many drawbacks of radiographic WL determination are eliminated by the electronic method. Measuring the length from the coronal reference point to the apical...
Materials and Methods

After obtaining institutional ethical committee clearance, a total of 40 patients undergoing extractions for orthodontic, periodontal, and prosthodontic reasons were included in this study. Study procedure was explained and informed consent was obtained from the patients. The inclusion criteria were tooth with completely formed apices and has enough crown structure in order to obtain a stable reference point. Patients with cardiac pacemakers as well as those having teeth with root resorptions and calcifications were excluded. Single operator performed the WL determination on the patient and after extraction of the tooth, while another operator noted down the WLs. After local anesthesia administration and isolation with rubber dam was carried out, an Endo Access Bur (Dentsply Maillefer, Ballaigues, Switzerland) and Endo-Z Bur (Dentsply Maillefer, Ballaigues, Switzerland) were used for access cavity preparation and refinement of the prepared access, respectively. The canals were located and the canal patency was established using a size 10 K-Files (M-Access, Dentsply Maillefer, Ballaigues, Switzerland). Rotary ProTaper SX files (Dentsply Maillefer, Ballaigues, Switzerland) were used in brushing motion for coronal third enlargement and to obtain a straight-line access. Continuous irrigation with 3% NaOCl was carried out to clear the pulp chamber contents.

A total of 40 patients were randomly divided into two groups of 20 each (n = 20): Group I (3% NaOCl) and Group II (2% CHX). Single operator had performed WL determination and another operator has performed the measurement of the file.

**Group I: 3% NaOCl**

The tooth was irrigated with 3% NaOCl and a syringe was used to aspirate the excess from the canals, leaving the canals moist. The patient’s lip was attached with the lip clip of Root ZX and the electrode was connected to a 15 size stainless-steel K-file. The file was advanced into the canal till the reading on the apex locator showed at least a single red bar (indication—beyond apex). Then the file was withdrawn till the EAL showed the last green bar and gave an audible beep signal for 5 sec. The rubber stop was adjusted to the coronal reference point and the electronic working length (EWL) was measured by Endo-M-Block (Dentsply Maillefer, Ballaigues, Switzerland); mean of three readings was considered. Then in the same patient, lip clip of the VDW Gold IAL was placed on the lip of the patient and a ProTaper shaper 1 file was used. The endomotor was set at the auto stop function. Under constant rotation, the file was advanced into the canal in a pecking motion till the file stopped due to the auto stop function. Then the readings were noted down similar to that of EAL.

**Group II: 2%CHX**

The canals were rinsed thoroughly with the help of saline so as to remove NaOCl used during initial cleaning to remove the canal contents. After irrigating with 2% CHX, a syringe was used to aspirate the excess CHX. WL was established similarly as mentioned earlier with both IAL and EAL.

**Determination of actual working length**

The actual working length was calculated according to Gomes et al. After removing rubber dam, each tooth was extracted and stored in 3% NaOCl for 15 min to remove residual organic tissue. Each root is examined for fractured root or any crown fracture. Teeth are stored in 0.9% saline solution until use.
A no. 10 K-Files was advanced into the canal until the file was visible through major AF under 20× magnification (dental operating microscope), and the file was withdrawn until the tip was just flushing with the major foramen. Silicon stopper was adjusted at coronal reference point. Length was measured and 0.5 mm was subtracted to get actual working length (AWL). In each case, AWL was subtracted from EWL. Positive values indicated longer WLs and the negative values indicated short WLs.

**Statistical analysis**

Data were analyzed with the Statistical Package for the Social Sciences (SPSS), version 21.0 (Released 2012; IBM Corp., Armonk, NY). The following test was used: paired dependent mean $t$ test (two tailed).

**RESULTS**

The mean WL was $21.55 \pm 1.9 \text{ mm}$ for the Root ZX and for VDW it was $21.530 \pm 1.9 \text{ mm}$, whereas the mean AWL was $21.67 \pm 1.8 \text{ mm}$ in NaOCl group [Table 1]. In 2% chlorhexidine group, the mean WL was $17.5 \pm 2.5 \text{ mm}$ for the Root ZX; for VDW it was $17.5 \pm 2.5 \text{ mm}$, and the mean AWL was $17.5 \pm 2.5$ [Table 2].

The paired sample independent $t$ test showed that there was no statistical significant difference between the Root ZX and VDW IAL in determining the minor foramen in both groups when compared with AWL.

**DISCUSSION**

Correct WL determines the treatment outcome of root canal therapy, thus ensures removal of the contents of the root canal system followed by filling prepared root canal space up to the WL without under or over extension of the final filling material.\textsuperscript{[1,18]} 

*In vivo* studies more closely reflect the reality of conditions in clinical practice.\textsuperscript{[9]} This study was conducted to compare and evaluate the efficiency of VDW IAL and Root ZX Mini (EAL) in two different irrigation solutions in *in vivo*. *In vitro* studies on the accuracy of EALs are problematic, as the human periodontium is excluded. Many *in vitro* studies have been conducted to show the effect of irrigant on the function of apex locators.\textsuperscript{[19,20]} During fabrication of *in vitro* model, the electrolyte may be forced into the canal space and give rise to inaccuracy.\textsuperscript{[5]} In this study, Endo-M-Block was used to measure the WL as 0.5 mm calibration is more practical and easy to transfer, and can be clinically reproduced when compared to that of 0.01 mm.\textsuperscript{[21]}

Root ZX Mini apex locator was included in this study as it is considered as a gold standard in accuracy, which is supported by various *in vitro* and *in vivo* studies.\textsuperscript{[19,20,22,23]} It is a third-generation EAL with an accuracy of 74%–97.37%.\textsuperscript{[24]} The principle mechanism by which this apex locator works is by calculating the impedance by the ratio of two frequency simultaneously, that is, “quotient method”. As the apex is reached, the quotient of the impedances decreases quickly and this device does not require any calibration.\textsuperscript{[25]} VDW Gold used in this study is endo motor with IAL. For an IAL to determine the WL during instrumentation in the canal and in the presence of various irrigating solutions is more of importance than an apex locator that is used for WL determination alone.

NaOCl was used in this study as it is a widely used irrigant. Advantages of NaOCl is the ability to dissolve tissues and also has antibacterial activity,\textsuperscript{[26]} was used in this study. Results showed that concentration of NaOCl does not adversely affect the WL determination of the IAL and EAL though there were some readings that were shorter than that of AWL, but the result was

| Groups       | Mean   | N   | Std. deviation | Std. error mean | $P$ value |
|--------------|--------|-----|----------------|-----------------|-----------|
| 3% NaOCl     |        |     |                |                 |           |
| AWL_group I  | 21.6750| 20  | 1.80842        | 0.40438         | 0.234     |
| Root ZX_group I | 21.5500| 20  | 1.99934        | 0.44707         |           |
| 3% NaOCl     |        |     |                |                 |           |
| AWL_group I  | 21.6750| 20  | 1.80551        | 0.40372         | 0.453     |
| VDW          | 21.5300| 20  | 1.99934        | 0.44707         |           |

| Groups       | Mean   | N   | Std. deviation | Std. error mean | $P$ value |
|--------------|--------|-----|----------------|-----------------|-----------|
| CHX          |        |     |                |                 |           |
| Root ZX_group II | 17.50  | 20  | 2.50578        | 0.56031         | 0.085     |
| AWL_group II | 17.55  | 20  | 2.46488        | 0.55117         |           |
| CHX          |        |     |                |                 |           |
| VDW_group II | 17.52  | 20  | 2.50513        | 0.56016         | 0.087     |
| AWL_group II | 17.55  | 20  | 2.46488        | 0.55117         |           |
not statistically significant (P < 0.05). This result was in accordance with the studies performed earlier.\textsuperscript{[22,23]} In the present study the ability of the WL determination (0.5 mm short of apex) by IAL was about 90% and for that of EAL was about 95% of times in 3%NaOCl.

2\% Chlorhexidine is commonly used as a final endodontic irrigant. The advantages of CHX are broad antibacterial spectrum, showing effectiveness against \textit{Enterococcus faecalis}\textsuperscript{[27]} and \textit{Candida albicans};\textsuperscript{[28]} low toxicity, does not bleach, and better odor, taste,\textsuperscript{[27]} and substantivity.\textsuperscript{[29]} In this study, results showed that chlorhexidine does not adversely affect the working length determination of both IAL and EAL with a 95% of accuracy of both the apex locators. This result was in accordance with studies done earlier.\textsuperscript{[30]}

Previous studies showed that CHX group was closest to the actual length.\textsuperscript{[31]} This finding was confirmed in this study. CHX group showed shortest distance to the apex than that of NaOCl group for both the apex locator measurements. This result could be due to the difference of electrical conductivity of the solutions used. The ability of different types of matter to conduct an electric current is known as electrical conductivity. NaOCl showed slightly shorter WLs due to its higher electrical conductivity when compared to that of CHX.\textsuperscript{[19]}

\textbf{Conclusion}

Within the limitations of this study, it can be concluded that both the apex locators IAL and EAL were equally effective in determining WL at 0.5 mm from the apex in the presence of NaOCl and chlorhexidine. The results show that EAL device is an adjunct in endodontic practice to determine the working length with accurate results that are consistent. While the IALs are provided with an auto stop function (the file in the canal stops once the apex is reached). This function can be effectively utilized to stop at 0.5 mm short of apex during instrumentation of the canal.

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\textbf{Conflicts of interest}

There are no conflicts of interest.

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