Influence of Apical Periodontitis on the Accuracy of 3 Electronic Root Canal Length Measurement Devices: An *In Vivo* Study

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Abstract

Introduction: The aim of this *in vivo* study was to evaluate the influence of apical periodontitis (AP) on the accuracy of Dentaport ZX (J Morita, Kyoto, Japan), Raypex 5 (VDW, Munich, Germany), and i-Root (S-Denti, Seoul, Korea) electronic root canal length measurement devices (ERCLMDs). **Methods:** Thirty-two single-rooted teeth scheduled for extraction, consisting of 16 teeth with AP and 16 teeth with normal periapex (NP), were selected. The access cavity was prepared, and the coronal portion of the canal was flared. The electronic working length (EWL) was determined by each ERCLMD according to each manufacturer's instructions. Each tooth was extracted, and the actual working length (AWL) was determined by inserting a size 15 K-file until the tip could be seen at a position tangential to the major foramen and then 0.5 mm was subtracted from the measurement. The distance from the file tip (EWL) to the point 0.5 mm coronal to the major foramen (AWL) was calculated. Data were analyzed using the nonparametric Fisher exact test and the chi-square test. Statistical significance was set at $P < .05$. **Results:** The accuracies of Dentaport ZX, Raypex 5, and i-Root within $\pm$0.5 mm in the AP group were 93.8%, 81.3%, and 75.0%; they were 93.3%, 86.7%, and 73.3% in the NP group, respectively. There were no significant differences between the accuracy of each device in the 2 groups ($P > .05$). Considering the 2 groups of AP and NP, there were no statistically significant differences in the accuracy of the ERCLMDs ($P > .05$). **Conclusions:** The presence of AP did not influence the accuracy of ERCLMDs. *(J Endod 2014;40:355–359)*

Key Words

Apical periodontitis, Dentaport ZX, electronic apex locators, i-Root, Raypex 5, working length

Working length (WL) determination is one of the most important factors for successful root canal treatment (1). Under- or overestimation of the WL may lead to the failure of treatment (1, 2). Cementodentinal junction is an ideal point for the termination of canal preparation and filling. However, it is a histologic landmark and cannot be determined precisely clinically (3). Therefore, most clinicians prefer to end canal preparation at the apical constriction or minor apical foramen, where the contact between the root canal filling material and apical tissues is minimal (4).

Electronic measurement of the WL was first proposed by Custer (5). Since then, many electronic devices based on different operating principles and electronic methods have been introduced. Although they do not assess the position of the root apex, they are generally called electronic apex locators. Thus, the use of an electronic root canal length measurement device (ERCLMD) as a generic name is more appropriate (6). The devices are sometimes classified by "generation," which is not helpful to clinicians. In addition, the information provided by manufacturers is often too limited to make it possible to classify them, and, thus, it is better suited for marketing issues (6).

Root ZX (J Morita, Kyoto, Japan) measures the canal length based on the ratio method, which simultaneously measures impedance values at 2 frequencies (0.4 and 8 kHz) and calculates a quotient of impedances (7). This ratio is independent of the presence of various intracanal contents and irrigants (8). The accuracy of Root ZX is not significantly different between the *in vivo* and *in vitro* models (9). Dentaport ZX is an updated version of Root ZX, which is comprised of an original Root ZX and an attached rotary motor device (10). Raypex 5 (VDW, Munich, Germany) measures the impedance at 2 frequencies (0.4 and 8 kHz) but uses 1 frequency at a time and the measurement is based on the root mean square values of the signals. According to the manufacturer, this method increases its accuracy and reliability (6, 11). i-Root (S-Denti, Seoul, Korea) operates on the same principle as Root ZX. However, the frequencies used in i-Root are 0.5 and 5 kHz, which are different from those of Root ZX (12).

Apical periodontitis (AP) is primarily an infectious disease of periapical tissues with an endodontic origin. Its prevalence has been reported in 30%–50% of individuals (13). AP activates immune/inflammatory responses, resulting in changes in periapical tissues (14). Apical root resorption is a more common event in teeth with AP than usually anticipated because radiographs often cannot provide sufficient diagnostic signs of the initial stages of root resorption (15). It can alter the morphology of the root apex, resulting in apical canal diameter enlargement, apical foramen deviation, and partial or even complete distortion of the apical constriction (16, 17). The morphology of root apex, such as the diameters, shapes, and locations of minor and major foramina,

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influences the accuracy of ERCLMDs (18). Therefore, AP might influence the accuracy of ERCLMDs. Thus, the aim of this *in vivo* study was to evaluate whether AP influences the accuracy of Dentaport ZX, Raypex 5, and i-Root ERCLMDs.

Materials and Methods

Thirty-two single-rooted teeth (13 maxillary incisors, 8 mandibular incisors, 5 maxillary second premolars, and 6 mandibular second premolars) with a single canal each scheduled for extraction because of periodontal or prosthodontic reasons were included in the study. There were 19 patients (6 women and 13 men) with an age range of 32–61 years. The Ethics Committee of Isfahan University of Medical Sciences approved the protocol of the study (no. 390553). Informed written consent was obtained from each patient at the beginning of the study. A periapical radiograph was taken for each tooth, and the periapical status was evaluated using the periapical index scoring system as described by Ørstavik et al (19). Pulp vitality was assessed using cold testing with Endo-Frost cold spray (Roeko; Coltene Whaledent, Langenau, Germany). The teeth were divided into 2 groups. The AP group included 16 teeth with clinical pulp necrosis and periapical index scores of 3, 4, or 5. The normal periapex (NP) group consisted of 16 teeth with clinical pulp vitality and a periapical index score of 1. The samples in this group had no restorations and no history of any trauma. Teeth with metal restorations, prosthetic crowns, pulp calcification, or previous endodontic treatment were not included.

Anesthesia was administered, and a dental dam was applied. The incisal edge or cusp tip was ground with a diamond wheel bur (818.FG.035; JOTA, Ruthi, Switzerland) in a high-speed handpiece to create a flat surface as a stable reference point. An endodontic access cavity was prepared, and the coronal portion of the canal was flared using sizes 4, 3, and 2 Gates-Glidden drills (Mani, Tochigi, Japan) in a step-down technique. Each canal was irrigated with 1% sodium hypochlorite solution and normal saline after each instrument. Excess fluid was aspirated from the pulp chamber. Electronic and actual working lengths were determined by an experienced endodontist similar to the technique used by Gomes et al (20).

For electronic WL (EWL) determination, the devices were used according to the manufacturers' instructions. The lip electrode was attached to the patient's lip, and the file electrode was connected to a size 15 K-file (Mani). With the Dentaport ZX and i-Root, the file was advanced within the root canal to the major foramen ("APEX" mark and signal) and then withdrawn until the display showed the 0.5-mm mark. With the Raypex 5, the file was advanced within the root canal to the major foramen (red line) and then withdrawn until the 3 green bars were reached. Measurements were considered valid when the reading remained stable for at least 5 seconds. A silicon stop was adjusted to the coronal reference point, the file was removed from the canal, and the distance between the silicon stop and the file tip was measured with a precision digital caliper (Mitutoyo Corp, Tokyo, Japan). After removing the rubber dam, each tooth was extracted and placed in 5.25% sodium hypochlorite for 15 minutes to remove any residual organic tissue from the root surface. Each tooth was then evaluated for the absence of an open apex or root fracture and stored in 0.9% saline solution.

For actual WL (AWL) determination, a size 15 K-file was advanced within the root canal until the file tip could be visualized through the major apical foramen under 16× magnification using a dental operating microscope (OPMI Primo; Carl Zeiss, Oberkochen, Germany). The file was then withdrawn until the tip was positioned tangential to the major apical foramen (Fig. 1), a silicon stop was adjusted to the coronal reference point, the file was removed from the canal, and the distance between the silicon stop and the file tip was measured with the digital caliper. Then, 0.5 mm was subtracted from the measurement. The operator repeated the measurements 3 times and recorded the mean of the values as the AWL. In each case, the AWL was subtracted from the EWL to determine the distance from the file tip (EWL) to the point 0.5 mm coronal to the major foramen (AWL). Positive values indicated measurements beyond the AWL (long), and negative values indicated measurements short of the AWL.

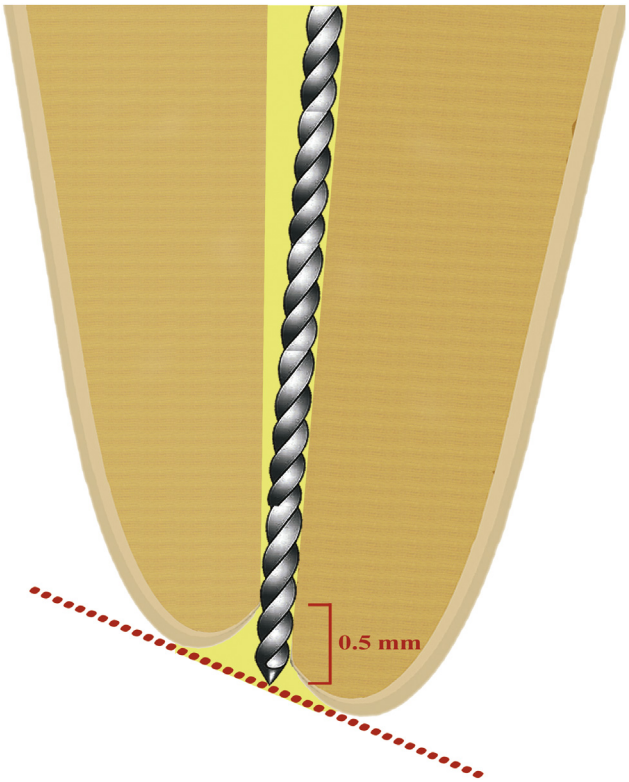

Figure 1. AWL determination. The tip of a size 15 K-file was advanced within the root canal and was positioned tangential to the major apical foramen. The apical landmark was considered at 0.5 mm coronal to the position.

One tooth was excluded from the NP group because of root fracture during extraction. Hence, 15 teeth in the NP group and 16 teeth in the AP group were included. The distance from the file tip (EWL) to the point 0.5 mm coronal to the major foramen (AWL) was calculated. Data were subjected to statistical analysis using SPSS Version 18 (SPSS Inc, Chicago, IL). The accuracy of each ERCLMD within ±0.5 mm was compared between the groups by using the nonparametric Fisher exact test. The relationship between both relevant variables of "ERCLMDs" and "apical status" was analyzed by using the chi-square test. Statistical significance was set at $P < .05$.

Results

The distances from the file tip (EWL) to the point 0.5 mm coronal to the major foramen (AWL) are shown in Table 1. The accuracies of Dentaport ZX, Raypex 5, and i-Root within ±0.5 mm in the AP group were 93.8%, 81.3%, and 75.0%; they were 93.3%, 86.7%, and 73.3% in the NP group, respectively (Table 2). There were no statistically significant differences between the 2 groups with respect to the accuracy of Dentaport ZX ($P = .742$), Raypex 5 ($P = .532$), and i-Root ($P = .618$). Considering the 2 groups of AP and NP, there were no statistically significant differences in the accuracy of Dentaport ZX and