Evaluation of the Reliability of Cone-beam Computed Tomography Scanning and Electronic Apex Locator Measurements in Working Length Determination of Teeth with Large Periapical Lesions

Yakup Üstün, DDS, PhD, Tuğrul Aslan, DDS, PhD,* Ahmet Ercan Şekerci, DDS, PhD,† and Burak Sağsen, DDS, PhD**

Abstract

Introduction: This study evaluates the endodontic working-length measurements in teeth with large periapical lesions and persistent intracanal exudate by using preexisting cone-beam computed tomography (CBCT). It compares the measurements with clinical root canal lengths determined by using 2 electronic apex locators. **Methods:** All patients had undergone a CBCT scan independent of the present study and needed root canal treatment of at least 1 tooth visible in the field of view. Seventy-three teeth with single roots and canals were studied. An endodontist measured each root canal length with 2 different electronic apex locators. The measurements were repeated 3 times by using a digital caliper, and the mean was recorded. This mean was compared with the root canal length as measured on CBCT sections by an oral radiologist not involved in the endodontic treatment. The CBCT measurements were taken twice for analysis of intrarater reliability. The data were statistically analyzed. **Results:** There were no significant measurement differences between the methods used ($P > .05$). **Conclusions:** In teeth with large periapical lesions and persistent intracanal exudate, measurement of the root canal length by using CBCT was as reliable as measurements that used apex locators. *(J Endod 2016;42:1334–1337)*

Key Words

Apex locator, cone-beam computed tomography, large periapical lesion, Propex Pixi, Raypex 6, root canal length measurement

Significance

The present study investigated the reliabilities of root canal length measurements performed with apex locators and cone-beam computed tomography scans in teeth with large periapical lesion and persistent intracanal exudate.

The determination of root canal preparation length is one of the crucial factors that can affect the outcome of endodontic treatment (1). Clinically, conventional radiography and electronic apex locators (EALs) are usually used to determine the working length (WL). This method depends on a two-dimensional radiographic image and has some limitations, including superpositioning of anatomic structures, errors that are due to image magnification, distortions, and sensitivity of the technique (2). Radiographically, the WL is often measured 0.5–1.0 mm short of the radiographic apex. In addition, the major foramen does not always coincide with the anatomic apex; it may be laterally located (3). Determination of the WL of the canal in teeth with apical lesions and apical root resorption can be difficult by using conventional radiography (4).

Electronic measurement of root canal length accurately determines the WL for root canal procedures (5), and this method has become indispensable in endodontics. Several studies have been performed to evaluate the accuracy of EALs (5–11), and EALs showed high accuracy rates, within 0.5 mm of the major apical foramen (8, 12). Several studies indicate that use of EALs reduces exposure of patients to radiation (13).

Propex Pixi (Dentsply Maillefer, Ballaigues, Switzerland) and Raypex 6 (VDW, Munich, Germany) are recently introduced multi-frequency apex locators. Studies have assessed their accuracy for determining WL (8, 11, 14). Electric conductivity of intracanal liquids (irrigants, blood, pulp, exudate, etc), immature apex formation, periapical lesions, apical foramen size, and file size used to measure root canal length can compromise the accuracy of EALs (7, 15–18). Two different apex locators were evaluated under consistent intracanal exudate, and the EALs were found to be accurate (6).

Cone-beam computed tomography (CBCT) has the advantage of a lower dose of radiation compared with computed tomography (19). Since its introduction in dentistry, CBCT has become an indispensable method for diagnosing root canal anatomy (20), root fracture (21), periapical pathology (14–17), and internal/external root resorption (22–24). CBCT is validated as a tool for exploring root canal morphology in

From the Departments of *Endodontics, and †Oral and Maxillofacial Radiology, Faculty of Dentistry, Erciyes University, Kayseri, Turkey.
Address requests for reprints to Dr Yakup Üstün, Department of Endodontics, Faculty of Dentistry, Erciyes University, Melikgazi, Kayseri 38039, Turkey. E-mail address: dtyakupustun@gmail.com
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3 dimensions (25), and in some studies it was also used for estimating the WL (10, 26, 27). CBCT measurements in combination with EALs may also be useful for determining the WL (26, 27).

The present study compared the accuracy of 2 EALs (Propex Pixi and Raypex 6) with a CBCT scan in determining apical foramen and WL in teeth with large periapical lesions and persistent intracanal exudate. The null hypothesis is that no differences exist between the measurement techniques.

Materials and Methods

The ethical board of the research foundation of Erciyes University of Medical Sciences in Kayseri, Turkey approved this investigation (Ethics Approval Number: 2016-249).

The present investigation included 30 patients who were referred to the Erciyes University Faculty of Dentistry, Department of Oral and Maxillofacial Surgery for further diagnostics and comprehensive therapy of large lesions of the jaws. All patients were in good general health, and female subjects were not pregnant. All patients had received limited CBCT imaging as part of the diagnostics of a large periapical lesion (>10 mm). A total of 73 teeth with a single root and canal from 30 patients were included in this study. Molar teeth or premolar teeth with several canals or roots, teeth that were not entirely visible in the CBCT scan or that had undergone any modifications after the CBCT scan, and CBCT scans with additional artifacts were not included in the study. Roots with severe apical resorptive defects and teeth with metallic restorations were not included in the study. The treatment plan consisted of an initial biopsy and subsequent endodontic treatment of the non-vital teeth and of the teeth in close proximity to the large lesion before the definitive surgery. In addition, a planned root canal treatment in at least 1 tooth with a single canal and root represented in the scanned field of view was required.

Imaging Procedures and Evaluation of WL Measurements on the CBCT Images

The CBCT images were obtained by using a NewTom 5G (QR, Verona, Italy) with a voxel size of 0.125 mm, positioned parallel to the horizontal axis of the alveolar bone. A single oral radiologist with 6 years of experience evaluated all CBCT images. Each CBCT image was evaluated twice, with a 7-day break between each evaluation. Only the first measurement was considered for the comparison with the EAL measurement. The CBCT images were analyzed in the NNT viewer, a simple version of the NNT software of the CBCT machine in a Dell Precision T5400 workstation (Dell, Round Rock, TX) and a 32-inch Dell LCD screen with a resolution of 1280 × 1024 pixels in a darkroom. The contrast and brightness of the images were adjusted by using the image-processing tool in the software to ensure optimal visualization. The CBCT slices were first reformatted to place the root canal of each analyzed tooth in a vertical position to visualize the incisal edge, pulp chamber, major foramen, and, if possible, the whole length of the canal in 1 single slice (Fig. 1). To ensure standardized measurements, the root canal length was established in the CBCT images as the distance between the most incisal (or the most cuspidal) tooth edge in the projected midline of the pulp cavity and the major foramen.

Clinically Working Length Determination by Using EALs

An expert endodontist completed all root canal treatment procedures. The endodontist was blinded to the results of the CBCT measurements. The clinical root canal length measurement was performed twice, once with each EAL according to the manufacturer's instructions. The EAL reference points used to determine the WL were the same points used in the CBCT measurements. After the tooth was anesthetized,

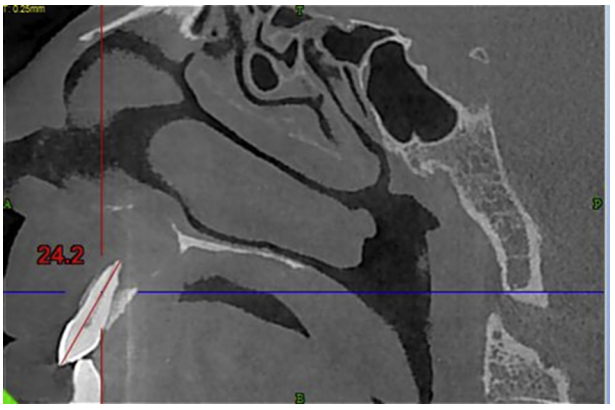

Figure 1. WL measurements by using CBCT scans.

the access cavity was opened, and the pulp was removed with a barbed broach. Apical patency was controlled with #8 K-File (Dentsply Maillefer). A #15 or bigger size K-file (Dentsply Maillefer) attached to the EAL device was then introduced into the root canal, and the lip hook of the EAL device was put onto the lip of the patient.

Working Length Determination with Propex Pixi. Measurements taken with Propex Pixi apex locator were determined following the manufacturer's instructions. When the 0.0 signal was seen by the operator, the file was gently moved beyond the apex until the "beyond apex" signal appeared, at which point the file was quickly withdrawn and stopped at the 0.0 point. Simultaneously, the rubber stop of the file was maintained in continuous contact with the incisal reference point of the tooth and fixed with flowable light-cure composite to the shaft of the file (Nova Compo HF Flow; Imicryl, Konya, Turkey). The distance was recorded by using a digital caliper (Insize Mini digital caliper; İstanbul, Turkey).

Working Length Determination with Raypex 6. The Raypex 6 was used according to the manufacturer's instructions. The measurements were taken with the "apex" mark as reference. The file was introduced to the major foramen (red ball point) and moved slightly beyond the apex. It was then retracted slightly to the zero point (red light), and the rubber stop of the file was then fixed to the incisal reference point of the tooth. The rubber stop was fixed to the shaft of the file, and the file was moved outward. The distance was recorded with a digital caliper.

The measurements were repeated 3 times with each EAL, and the mean value was recorded. The measurements were not recorded until the reading remained stable for at least 5 seconds; unstable measurements were not considered for statistical evaluation.

The teeth included in this study had intracanal exudate that leaked from periapical lesions. Therefore, endodontic treatments were performed until the leakage was depleted. Of the 73 teeth, 67 were obturated before the surgical operation, but the obturations of 6 teeth could not be perfomed during the treatment sessions. Those 6 teeth were obturated during the surgical operation. Most of the teeth included in this study were diagnosed as having pulp necrosis; those that were vital had root canal therapy because the subsequent surgery would devitalize them. All root canal preparations were performed by using Reciproc instruments (VDW) and an endodontic motor (VDW Silver; VDW). Root canals were irrigated with 1% NaOCl during instrumentation. After completion of the preparation, the canals were irrigated with 2 mL 17% ethylenediaminetetraacetic acid for 1 minute and subsequently rinsed with 2 mL distilled water. The root canals were then dried with paper points (Dentsply Maillefer). All root canal obturations were performed with gutta-percha and a resin-based root canal sealer by using a cold