The Accuracy of a New Cone-beam Computed Tomographic Software in the Preoperative Working Length Determination *Ex Vivo*

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Abstract

Introduction: This study investigates the accuracy of 3D Endo software (Dentsply Sirona, Salzburg, Austria) to determine the working length when using preoperative cone-beam computed tomographic (CBCT) scans of extracted teeth, compared with conventional CBCT software and an electronic apex locator (EAL). **Methods:** CBCT scans of 30 premolars were obtained. Using OnDemand3D software (Cybermed, Seoul, Korea), the measurement obtained from the coronal reference to the apical foramen (AF) was recorded as the conventional CBCT length. Then, using 3D Endo software (Dentsply Sirona), the suggested length (3D-SL) and the operator-adjusted length (3D-OL) were obtained. Teeth were accessed, and the actual length was measured. Finally, the teeth were embedded in alginate to obtain the electronic length (EL) using the EAL Root ZX (J Morita, Tokyo, Japan). The means of the absolute values and the percentages of distribution of the tested measurement methods were compared to the actual length. **Results:** No difference was found regarding the mean measurements (analysis of variance, $P > .05$). All the CBCT measurements presented a high reliability (Dahlberg's formula). The measurements within a ±0.5-mm range from the AF were 86.6% for the 3D-SL, 80% for the 3D-OL and EL, and 73.3% for the CBCT length. The EL presented significantly fewer underestimated measurements ($P < .05$). The 3D-OL and 3D-SL presented significantly fewer measurements beyond the AF ($P < .05$). **Conclusions:** The preoperative working length determination using 3D Endo was reliable and similar to conventional CBCT software. However, the combined use of CBCT with an EAL is required to increase the accuracy in the location of the AF. *(J Endod 2018;44:1024–1029)*

Key Words

3D endo, cone-beam computed tomography, electronic apex locator, endodontics, working length

Significance

3D Endo is CBCT software dedicated to endodontics that presents automated functions for preoperative working length determination. It was considered reliable and similar to conventional CBCT software, but measurements should be clinically confirmed using an apex locator.

The determination of a proper apical limit is critical for the success of endodontic treatment (1, 2). Under- or overestimation of the working length (WL) might result, respectively, in insufficient disinfection or damage to the periapical tissues (1, 2). The apical foramen (AF) is where the canal exits at the root surface, and the apical constriction (AC) is the smallest diameter of the canal. The AC is usually located 0.5–1 mm short of the AF, and it is considered the ideal end point for endodontic procedures (2).

Periapical radiographs and electronic apex locators (EALs) are currently the most used methods for intraoperative determination of the WL. EALs are more precise and reliable than radiographs (3, 4), but their performance might be affected by different situations such as anatomic complexities, lack of patency, or metallic restorations (3–6). On the other hand, limitations of conventional radiography are largely related to its bidimensional nature, which prevents accurate WL determination in cases with curvatures in the buccolingual (BL) plane, a lateral foramen, distortions, superimposition of anatomic structures, and difficulties with landmark identification (4, 7).

Cone-beam computed tomographic (CBCT) imaging is a contemporary radiologic imaging system that is useful in providing reliable anatomic information in 3 dimensions for diagnosis and treatment planning before endodontic therapy (8–12). A preexisting CBCT scan for any indication in dentistry might be potentially used for preoperative estimation of the WL (13–15). However, there is no consensus in the literature regarding the accuracy of CBCT measurements when compared with the traditional WL determination methods, such as EALs and radiographs (7, 13–19).

The discrepancy among different studies could be related to the methods used to obtain the WL in the scans, which rely on the measuring tools available in the CBCT software programs. Most of this software presents a ruler tool that can be used for

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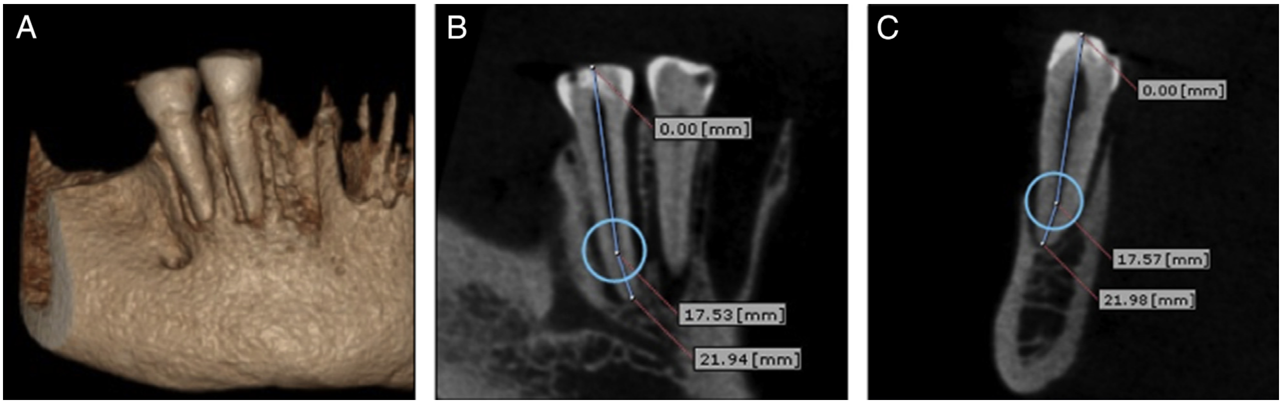

Figure 1. The 3D rendering (*A*) and working length obtained using OnDemand3D software in the (*B*) BL and (*C*) MD views.

measuring any given distances but usually in a selected bidimensional plane. In other words, the operator needs to locate the longitudinal view that can better represent the entire length of the canal to draw a line from the coronal reference to the apical foramen (16–18, 20). For curved canals, it has been suggested to use a segmented line to follow a curved canal trajectory in the different planes (14, 15, 19, 21) or to draw a horizontal line at the coronal reference point and connect it with the foramen in the other plane (20). In addition, some studies used the mean between the lengths from the mesiodistal (MD) and BL views in the CBCT scans as the WL measurement (14, 21). This variability in the methods might affect the repeatability and make it difficult to compare results from different studies (7, 16, 20).

Recently, 3D Endo software (Dentsply Sirona, Salzburg, Austria) has been developed for specific treatment planning of endodontic procedures (22). It presents an intuitive interface in which the clinician can follow steps for the identification and measurement of the canals as well as virtual planning of the access cavity, apical limit, and file selection for shaping procedures. A recent study reported that this software enhances the 3-dimensional (3D) visualization of the canal complexities such as curvatures and confluences (23). An innovative feature of this software is the semiautomated detection of the root canal trajectory; after identifying the orifice and AF, an automated line connecting them is generated, which can be adjusted to follow the canal trajectory in 3 dimensions. Using this trajectory as a reference, a virtual endodontic file can be used to estimate the WL, using either an automatic suggestion or manual adjustment by the clinician. This semiautomated detection of the canal trajectory has the potential to minimize subjective errors related to the operator's skills (21, 23, 24).

Although this software is designed for clinical use, it requires an initial laboratory investigation to validate these virtual WL estimations compared with the gold standard, which in this case is the actual extracted tooth length (13). In addition, it is also relevant to verify whether the semiautomated tools offer an advantage compared with the use of conventional software for CBCT analysis. Thus, this *ex vivo* study was designed to investigate the accuracy of the new 3D Endo software, conventional CBCT software (OnDemand3D; Cybermed, Seoul, Korea), and an EAL (Root ZX; J Morita, Tokyo, Japan) in WL determination.

Materials and Methods

This study was approved by the local ethics committee (protocol 2.348.485). Ninety extracted human single-rooted mandibular premolar teeth stored in 0.1% thymol solution and 1 dry mandible were obtained from the School of Health and Biosciences of the Pontifical Catholic University, Curitiba, Brazil. The teeth were evaluated under an operating microscope at 10× magnification (DF Vasconcellos, Londrina, Brazil) to exclude roots presenting cracks, calcified canals, immature apices, resorptive defects, caries, previous root canal access or filling material, and lateral foramina (6). The teeth were scanned by means of CBCT imaging to evaluate and standardize the anatomic parameters. CBCT scans were performed using the Scanora 3D (Soredex, Tuusula, Finland) at 120 kVp, 12.5 mA, field of view (FOV) of 75 × 100 mm, and 0.2-mm voxel size. Thirty standardized teeth presenting with Vertucci type I configuration, an apical curvature $<10°$, and an apical diameter up to 0.3 mm were obtained. The selected teeth were washed in saline, and buccal cusps were flattened to be used as a consistent and reproducible coronal reference for all the measurements.

CBCT Measurements

The teeth were numbered and randomly divided to be scanned 4 teeth at a time. For length measurement CBCT scans, each tooth was placed in a prepared, empty mandibular premolar socket of the dry mandible (16). The mandible was fixed at the base of a plastic container filled with water to simulate soft tissue (25) and scanned by means of a CBCT scanner (Scanora 3D) at 90 kV, 13 mA, FOV of 60 × 60 mm, and 0.133-mm^3 voxel size.

All CBCT scans were analyzed by 1 experienced endodontist. The images were manipulated using a personal computer running Microsoft Windows XP Professional (Microsoft Corp, Redmond, WA) on a 22.5-inch flat-screen monitor (resolution = 1920 ×1200 pixels).

In the first section, the images were analyzed using the CBCT OnDemand3D software. The selected tooth was vertically positioned and slightly rotated to obtain a single longitudinal slice that best represented the whole length of the canal in both the BL and MD views (19). A measuring line was traced from the occlusal reference (flattened buccal cusp) to the AF, centered in the canal, following any visible deviation (Fig. 1*A–C*). The average between the BL and MD measurements was recorded as the conventional CBCT length (CL).

After 2 weeks, the 3D Endo software was used in the same scans. The interface of this program presents 5 major steps. The first, "Diagnosis and Pathology," allows the traditional visualization of CBCT images and rendering (Fig. 2*A*). In the second step, "3D Tooth Anatomy," the tooth is individualized by using a crop tool to remove most of the surrounding tissues (Fig. 2*B*). Then, the operator can identify the "Canal System" (Fig. 2*C*) by selecting in the axial images the location of the orifice and AF of each canal followed by an automatic line that connects both landmarks. In the fourth step, "3D Canal