Feasibility of Cone-beam Computed Tomography in Detecting Lateral Canals before and after Root Canal Treatment: An *Ex Vivo* Study

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Abstract

Introduction: The study objective was to evaluate the effectiveness of cone-beam computed tomographic (CBCT) imaging for the detection of lateral canals (LCs) in endodontically treated premolars. **Methods:** Two evaluators classified 80 extracted premolars into 2 groups based on the absence (n = 40) or presence (n = 40) of LCs according to micro–computed tomographic analysis. The extracted teeth were fixated in a human mandible and scanned with CBCT imaging. Subsequently, each tooth was endodontically treated, and CBCT scans were repeated. Three experienced examiners evaluated all images randomly. Receiver operating characteristic curves were compared using the McNemar test, and sensitivity, specificity, positive predictive value, and negative predictive value (NPV) were obtained. **Results:** The area under the receiver operating characteristic curve values were 0.58 and 0.49 before and after root canal treatment, respectively. These values were statistically significantly different ($P < .001$). Before root canal treatment sensitivity, specificity, positive predictive value, and negative predictive value were 55%, 52%, 55%, and 56%, whereas after root canal treatment the values were 33%, 61%, 46%, and 48%, respectively. **Conclusions:** LC detection in nontreated teeth presented low accuracy, whereas among treated teeth CBCT imaging showed no efficacy. The results suggest that CBCT imaging is not an effective diagnostic tool for LC detection. *(J Endod 2017;■:1–4)*

Key Words

Cone beam computed tomography, diagnosis, lateral canal, root canal obturation

Significance

Adequate diagnosis and treatment of persistent infection in lateral canals poses a clinical challenge because of the high prevalence in permanent teeth. The study aim was to evaluate the effectiveness of CBCT imaging in identifying lateral canals in root-filled premolars *ex vivo*.

Failure of root canal treatment (RCT) resulting from incomplete canal debridement and obturation because of aberrant anatomic composition is a clinical reality. Research shows that at least 9% of endodontic failures could be attributed to complex canal morphology including the presence of apical ramifications and other morphologic aberrations (1, 2). Lateral canals (LCs) are ramifications connecting the main canal to the periodontal ligament that can exhibit different sizes and shapes (3, 4). These canals, also dubbed secondary canals when located in the apical third of the root (5), are frequently found to be perpendicular to the main canal and represent a challenge for endodontic diagnosis and treatment because they are extremely difficult to access, clean, disinfect, and fill (6). If they remain untreated, they could result in lateral lesions (7), which could be misdiagnosed as periodontally induced bone loss or root fractures. Detecting LCs before treatment or during the investigation of possible endodontic failure is crucial for determining the appropriate treatment protocol and predicting treatment outcome (8). Additional diagnostic tools are required to detect LCs because clinical observation is difficult to achieve, even with the use of an operating microscope.

One important imaging method that is currently accessible in clinical practice is cone-beam computed tomographic (CBCT) imaging. It allows a volumetric visualization of hard tissues with relatively low radiation dose while eliminating superimposition artifacts of anatomic structures routinely encountered in conventional 2-dimensional imaging (9). CBCT imaging was previously shown to reliably demonstrate anatomic variations regarding the main canal configuration (10–14). However, to the best of our knowledge, there is no investigation focusing on detecting LCs. Therefore, the objective of this study was to evaluate CBCT reliability in detecting LCs before and after RCT.

Materials and Methods

Sample Preparation

The study protocol was approved by the institutional review board. Eighty extracted maxillary and mandibular single- and multirooted premolars were cleaned, disinfected, and kept in physiologic solution. Roots with an open

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0099-2399/$ - see front matter

http://dx.doi.org/10.1016/j.joen.2017.01.025

apex, excessive restorations, or resorptive lesions were excluded. All teeth underwent micro–computed tomographic (μCT) examination using Skyscan 1174 (Bruker, Kontich, Belgium) with the following settings: 50 kV, 800 μA, voxel dimension of 15.91 μm, 1.0-mm-thick aluminum filter, rotation step of 0.4°, and 4 frames. Two experienced maxillofacial radiologists analyzed the images using CTAn software (v.1.14.4.1, Bruker) in order to classify the teeth according to the presence/absence and number of LCs. If a consensus could not be reached between the 2 examiners, a third examiner would assist in making the decision. The included teeth were separated into 2 groups: LC absent (n = 40) and LC present (n = 40) (Fig. 1*A* and *B*). The widest diameter of LCs was also measured to assess the possible correlation between LC detection and size.

CBCT Data Collection

Each tooth was placed in a dry mandible (socket position: 29) and scanned using 3D AccuiTomo 170 (Morita Inc, Osaka, Japan) with the following protocol: field of view of 4 × 4, voxel size of 0.08 mm, 90 kVp, and 5 mA. Water was used to simulate soft tissues as previously described in the literature (15).

Three experienced examiners evaluated the CBCT volumes independently and scored the LC detection on a 5-point rank scale: 1, LC definitely present; 2, LC probably present; 3, unsure whether present or absent; 4, LC probably absent; and 5, LC definitely absent (16).

Subsequently, root canals were prepared with the Mtwo rotary system (VDW Silver; VDW GmbH, Munich, Germany) until file size 40. Sodium hypochlorite 2.5% was used for canal irrigation followed by administering 17% EDTA. Teeth were filled with a single-cone technique with Mtwo gutta-percha (VDW GmbH) and AH 26 sealer (Dentsply DeTrey GmbH, Konstanz, Germany) per the manufacturers' instructions. CBCT acquisitions were repeated using identical settings. The images were randomized and analyzed 30 days after the first evaluation. For intra-agreement analysis, 25% of the images were randomly reviewed 30 days later. Finally, μCT acquisitions of the treated teeth were repeated, aiming to investigate whether LCs were filled, partially filled, or not filled.

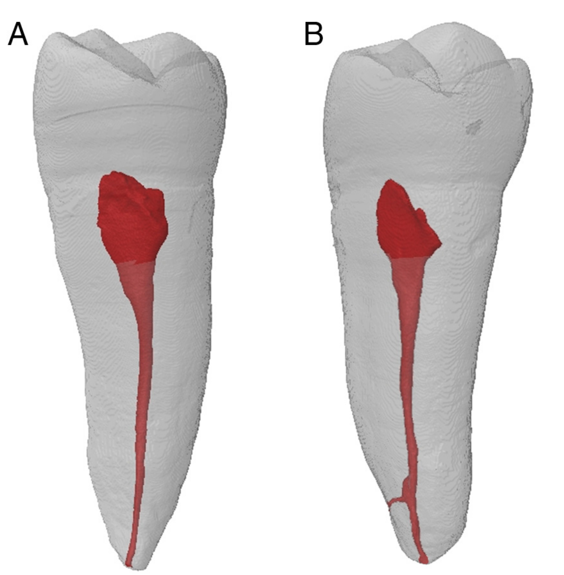

Figure 1. μCT 3-dimensional reconstruction. (*A*) An example of a tooth with absence of an LC. (*B*) An example of a tooth with an LC.

Statistical Analysis

Data were analyzed using SPSS for Windows (v. 22; SPSS Inc, Chicago, IL). Receiver operating characteristic (ROC) curve analysis was plotted to evaluate CBCT diagnostic accuracy before and after RCT. The areas under the curves were compared using the McNemar test, and the level of significance for rejecting the null hypothesis was set at 5% (α = 0.05). To calculate sensitivity, specificity, positive predictive value, and negative predictive value, the evaluators' responses were dichotomized into the presence or absence of LCs. Scores of 1 and 2 were considered as LCs present and scores of 3, 4, and 5 as LCs absent (16). The Spearman correlation coefficient was performed to verify a possible positive correlation between the maximum diameter of LCs and evaluators' responses. Kappa test assessed the reliability of the intra- and interevaluators.

Results

Accuracies were obtained from the areas under the ROC curves, considering the 5 previously defined scores. The CBCT ROC curves before and after RCT are shown in Figure 2. Before RCT, an area value of 0.58 ($P < .05$) was obtained, and after RCT an area value of 0.49 ($P > .05$) was calculated. The differences between both areas were statistically significantly different ($P < .001$) (Fig. 3). Sensitivity, specificity, positive predictive value, and negative predictive value for CBCT evaluations before and after RCT are shown in Table 1. The largest diameter of LCs as assessed using μCT was 0.14 ± 0.04. The Spearman coefficient showed no correlation between LC diameter and evaluators' responses ($P > .05$). μCT analysis after RCT showed that of 40 treated teeth, 13 were fully filled with sealer, 9 were partially filled, and 18 were totally empty. Intra- and interevaluator agreement ranged from moderate (0.59) to substantial (0.67) and fair (0.26) to moderate (0.56), respectively (17).

Discussion

This *ex vivo* study investigated the detection accuracy of LCs with CBCT imaging before and after nonsurgical RCT. The area under the ROC curve calculated for nontreated teeth was low, whereas the area for treated teeth was not statistically significant. When evaluating areas under the ROC curve, an ideal diagnostic test should be close to 1.0 (with a curve distancing from the reference line), whereas values below 0.5 indicate no effectiveness (18). The value of 0.58 obtained in this

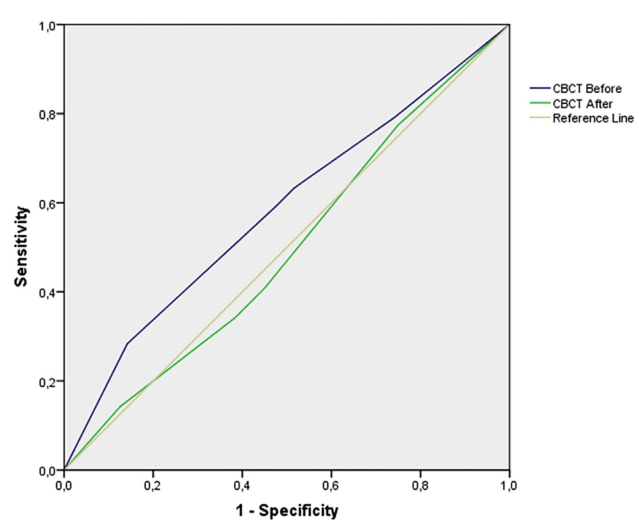

Figure 2. ROC curves for CBCT accuracies before and after RCT.