# Diagnostic Accuracy of Periapical Radiography and Cone-beam Computed Tomography in Identifying Root Canal Configuration of Human Premolars

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## Abstract

**Introduction:** The aim of this study was to assess the diagnostic accuracy of periapical radiography (PR) and cone-beam computed tomographic (CBCT) imaging in the detection of the root canal configuration (RCC) of human premolars. **Methods:** PR and CBCT imaging of 114 extracted human premolars were evaluated by 2 oral radiologists. RCC was recorded according to Vertucci's classification. Micro–computed tomographic imaging served as the gold standard to determine RCC. Accuracy, sensitivity, specificity, and predictive values were calculated. The Friedman test compared both PR and CBCT imaging with the gold standard. **Results:** CBCT imaging showed higher values for all diagnostic tests compared with PR. Accuracy was 0.55 and 0.89 for PR and CBCT imaging, respectively. There was no difference between CBCT imaging and the gold standard, whereas PR differed from both CBCT and micro–computed tomographic imaging ($P < .0001$). CBCT imaging was more accurate than PR for evaluating different types of RCC individually. Canal configuration types III, VII, and "other" were poorly identified on CBCT imaging with a detection accuracy of 50%, 0%, and 43%, respectively. With PR, all canal configurations except type I were poorly visible. **Conclusions:** PR presented low performance in the detection of RCC in premolars, whereas CBCT imaging showed no difference compared with the gold standard. Canals with complex configurations were less identifiable using both imaging methods, especially PR. *(J Endod 2017;■:1–4)*

## Key Words

Anatomy, cone-beam computed tomography, dental pulp cavity, endodontics, radiography

**Significance**

Adequate diagnosis and treatment of root canals are challenging because of their anatomic complexity. Periapical radiography and CBCT imaging have an important role in daily practice. The study aim was to evaluate their effectiveness in identifying root canal configurations in extracted premolars.

The anatomy of root canals has long been investigated in the literature since pioneer *in vitro* studies showed how complex the internal tooth morphology can be (1). Indeed, knowledge of root canal configuration (RCC) is crucial to achieve treatment success because it assists in drawing up an appropriate plan and, consequently, avoids possible technical failures at all stages of treatment (2–4). Periapical radiography (PR) is the most widely adopted method to evaluate root canal anatomy in clinical practice (5). This simple technique provides complementary information at a relatively low cost and radiation dose. However, despite its widespread use, PR fails to depict the complex anatomic configuration of teeth because of image overlapping inherent to conventional 2-dimensional radiography.

Cone-beam computed tomographic (CBCT) imaging provides high-quality, accurate, 3-dimensional (3D) representations of hard tissues, resulting in a more accurate diagnosis of many conditions (6). Although it is not indicated for the initial evaluation of dental morphology, CBCT imaging may be considered when it has been decided that radiographic images are yielding limited information and that further details are required for diagnosis and treatment planning (7).

Many studies have used both PR and CBCT imaging to identify RCC in different populations with no gold standard or have simply used CBCT imaging as the reference method (8–11). However, the assumption that CBCT scanning is accurate enough to diagnose RCC without comparing it with a gold standard can underestimate the complexity of RCC. Therefore, the precision and biases of RCC frequency-based studies cannot be estimated because of the lack of knowledge of the accuracy of CBCT imaging in detecting RCC.

Micro–computed tomographic ($\mu$CT) imaging is often used as the gold standard because of its high spatial resolution, which allows endodontic features to be evaluated in detail without the destruction of samples (12). To the best of our knowledge, the efficacy of CBCT imaging and PR (which is the most common imaging modality) in

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identifying RCC of human premolars supported by a gold standard method has not been investigated yet. This study aimed to assess the diagnostic accuracy of PR and CBCT images in detecting RCC of human premolars using $\mu$CT imaging as the gold standard.

## Materials and Methods

### Data Collection

After local ethics committee approval (protocol number 154/2015), 114 single- and 2-rooted extracted human premolars were collected, cleaned, and disinfected. Maxillary (11 first and 45 second) and mandibular (34 first and 24 second) premolars were included. Exclusion criteria consisted of teeth with root canal treatment, calcification, incomplete root formation, resorptive lesions, or fractures. To simulate clinical conditions, the teeth were placed in a dry mandible in the premolar region covered with wax. Periapical radiographs were obtained with the paralleling technique using a dental X-ray device (Focus; Instrumentarium, Tuusula, Finland) and the VistaScan intraoral digital system (Dürr Dental, Beitigheim-Bissinger, Germany) operating at 7 mA, 70 kVp, and 0.06 seconds. CBCT scans were performed using the 3D Accuitomo device (J Morita Manufacturing, Kyoto, Japan) with a high-resolution protocol (field of view: 4 × 4, a voxel size of 0.08 mm, 90 kVp, and 5 mA). Before CBCT scanning, the mounted dry mandible was submerged in water in a 12 × 7.5 × 7 cm plastic container to simulate the natural effect of radiation attenuation and scattering produced by soft tissues (13). The teeth were then scanned on a Skyscan 1174 $\mu$CT unit (Bruker, Kontich, Belgium) using the following settings: 50 kV, 800 $\mu$A, a 15.91-$\mu$m voxel size, a 1.0-mm aluminum filter, a rotation step 0.4°, and 4 frames.

### Image Assessment

The data set (PR and CBCT images) was randomized and evaluated independently by 2 oral radiologists with more than 5 years of experience in diagnostic imaging. First, RCC was assessed in periapical radiographs using ImageJ software (National Institutes of Health, Bethesda, MD), and each main canal was classified according to Vertucci (14) (Fig. 1). Root canals with a configuration other than the ones present in Vertucci's classification were assigned as "other." CBCT images were randomized and evaluated using CS 3D Imaging Version 3.5.7 software (Carestream Health Inc, Rochester, NY) dynamically in the multiplanar reconstruction mode. Zoom, brightness, and contrast tools were available to be used for both periapical and CBCT evaluations. After PR and CBCT evaluations, $\mu$CT images were analyzed by 2 other independent evaluators using CTAn software (v.1.14.4.1; Bruker, Kontich, Belgium) to obtain the gold standard. In case of disagreement in any imaging modality, images were re-evaluated by consensus of the 2 evaluators. For each imaging modality, a second evaluation was performed under the same conditions with 20% of the sample to assess the method's reproducibility.

### Statistical Analysis

Data were analyzed using SPSS software for Windows (Version 22; SPSS Corp, Chicago, IL). Values of accuracy, sensitivity, specificity, positive predictive value, and negative predictive value were obtained. A comparison among PR, CBCT, and $\mu$CT findings was performed using the Friedman test with a significance level ($\alpha$) of 5%. The kappa test was performed to assess intraobserver reliability.

## Results

Vertucci's types of RCCs identified after $\mu$CT analysis were type I (49.18%), type II (2.46%), type III (3.28%), type IV (7.38%), type V (12.29%), type VI (4.1%), and type VII (2.46%), and 18.85% of the canals were categorized as "other." There was no type VIII configuration in the sample. CBCT imaging showed consistent diagnostic results and higher accuracy than PR (Table 1). PR showed low diagnostic values, except specificity. The Friedman test found no difference between CBCT imaging and the gold standard, whereas PR significantly differed from both CBCT and $\mu$CT imaging ($P < .0001$) (Fig. 2).

Table 2 details the comparison of PR and CBCT imaging with the gold standard, considering different types of RCC individually. Overall, CBCT identification was more accurate than PR. Types III, VII, and "other" had the poorest detection scores using CBCT imaging (50%, 0%, and 43%, respectively). In PR evaluation, except for type I, all other higher-complexity types presented critical identification; only 2 of 66 canals were correctly identified. In 77% of these mistaken answers, type I was the most common reported answer.

Kappa values for intraobserver reproducibility for PR and CBCT imaging were considered almost perfect agreement and substantial agreement (0.83 and 0.78, respectively) according to the classification of Landis and Kock (15).

## Discussion

This study is the first in which PR and CBCT imaging were tested and compared regarding the correct identification of RCC in premolars using $\mu$CT imaging as the gold standard. CBCT imaging was more accurate than PR in the assessment of 122 root canals and provided better results in all diagnostic tests. When confronting the data from the 3 imaging modalities, CBCT imaging did not differ from $\mu$CT imaging, whereas PR significantly differed from both.

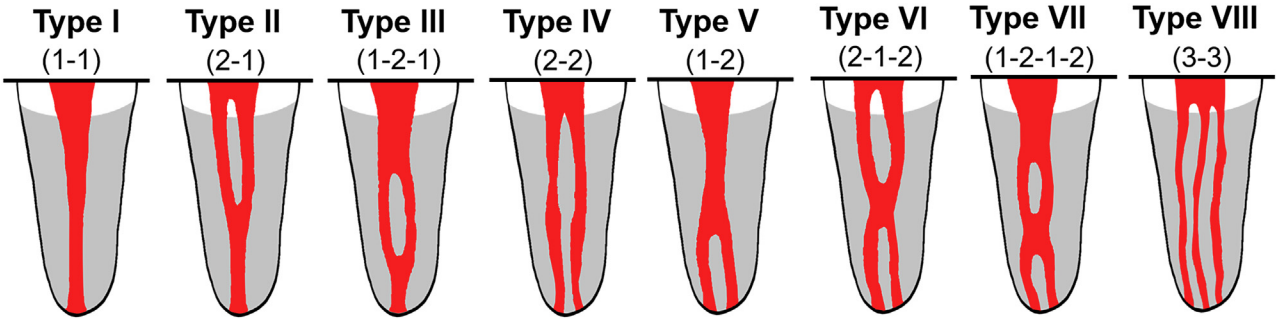


**Figure 1.** Vertucci's classification of root canal configuration: type I, a single canal; type II, 2 canals that converge near the apex; type III, a canal that is divided in 2 but converges again near the apex; type IV, 2 independent canals; type V, a canal that is divided in 2 before the apex; type VI, 2 canals that converge within the root and are divided again into 2 canals; type VII, a canal that is divided and then converges within the root and is again divided into 2 before the apex; and type VIII, 3 independent canals.