Evaluation of the Root Canal Anatomy of Maxillary and Mandibular Premolars in a Selected German Population Using Cone-beam Computed Tomographic Data

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Abstract

Introduction: The aim of this study was to investigate the number of roots and the morphology of the root canals of maxillary and mandibular premolars in a selected German population. **Methods:** Randomly selected full-size cone-beam computed tomographic images were collected from 700 patients (45% men and 55% women, average age = 50.21 years). This resulted in a total of 644 first and 512 second maxillary premolars as well as 1044 first and 871 second mandibular premolars. The total number of roots and root canals, the frequency and correlations between the left and right sides, and the incidence in men and women were recorded and statistically analyzed using the Fisher exact and chi-square tests. Canal configurations were classified according to the Vertucci classification. **Results:** First maxillary premolars mainly had 2 roots (1 root: 36.4%, 2 roots: 62.4%, and 3 roots: 1.2%) with predominantly 2 canals (88.4%). The majority of second maxillary premolars had 1 root (82.6%), but 2 root canals (56.3%) occurred more frequently than 1 canal (43.1%). In the first and second mandibular premolars, 1 root was found predominantly (90.76% and 98.16%, respectively) with 1 canal (77.9% and 96.0%), whereas 2 canals were less common (21.9% and 3.6%). Three roots (0%, <0.11%) and 3 canals (0.2%; 0.4%) were rarely found. Vertucci classifications were heterogeneously distributed. Men showed significantly more roots and root canals compared with women ($P < .05$), with the exception of the second mandibular premolars. **Conclusions:** This cone-beam computed tomographic study confirmed previous anatomic and morphologic investigations. When treating premolars, the likelihood of additional root canals should be considered. *(J Endod 2017;■:1–5)*

Key Words

Cone-beam computed tomography, mandibular premolars, maxillary premolars, root canal anatomy, root canal configuration

Significance

Root canal treatment of maxillary and mandibular premolars is challenging, and the likelihood of additional roots and root canals should be considered. Premolars of male patients present significantly more roots and root canals compared with women.

Since the last century, the complexity of internal and external anatomic variations of roots and root canals has been documented. The first attempts were made by Hess and Zurcher (1), who visualized lateral canals and isthmi (1). Vertucci et al (2) suggested a classification that is still used despite the recent implementation of further subclasses. Numerous techniques have been developed and implemented to investigate root canal anatomy, such as canal staining and tooth clearing (3, 4), visual and conventional radiography (5, 6), alternative radiographic techniques (7), and modified root canal staining techniques (8).

Recently, micro–computed tomographic (μCT) imaging has been used for anatomic studies. This method allows the root canal system to be assessed noninvasively and 3-dimensionally (9–11); μCT analyses are useful for training purposes and provide researchers and clinicians with valuable additional information about the complexity of the root canal system (9). However, these studies are time-consuming, and results were based mainly on relatively small sample sizes. The better the diagnostic methods became the more subgroups of root canal classifications were proposed (12). Hence, recently, a new system for classifying roots and root canal systems was proposed based on Vertucci et al's classification (2) to simplify research, clinical practice, and training (13).

Because of the limitation of μCT studies with extracted teeth, other 3-dimensional data from medical computed tomographic imaging or cone-beam computed tomographic (CBCT) imaging may be helpful for the assessment of anatomic variations of teeth. Additionally, ethnic variability can better be taken into consideration in investigations *in vivo*. The sex and origin of patients are usually listed in the medical history, and other preexisting data are available. Acquired data from CBCT scans are well suited for anatomic and morphologic evaluations of root canal classifications (14–18).

Because of the variability of the root canal morphology, especially in maxillary and mandibular first and second premolars, root canal treatment is challenging, and the treatment outcome may be reduced (19). The knowledge of the root and root canal morphology is crucial for proper chemomechanical disinfection of the entire root canal

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0099-2399/$ - see front matter

http://dx.doi.org/10.1016/j.joen.2017.03.044

system. These teeth often present an 8-shaped cross section with 1 or up to 3 roots that may occur fused or separated. Additionally, different furcation levels hamper a proper radiographic determination of the apical borders (20) to determine the working length correctly. Even with eccentric radiographs, important details may be superimposed by adjacent structures.

Numerous studies investigated the prevalence of roots and root canals, and a huge variability was documented dependent on the selected method and the ethnic groups. A recently published review showed that the majority of maxillary first premolars had 1 (41.7%) or 2 roots (56.6%). Regardless of the number of roots, the vast majority (86.6%) had 2 root canals, with type IV (2-2) being the most common canal configuration (64.8%) (14). The second maxillary premolar presents 1 canal at the apex in about 75% of cases and 2 canals at the apex in 24% of cases. Vertucci classification is relatively heterogeneously distributed (2).

Concerning mandibular first and second premolars, the morphology also shows some variations. The mandibular first premolar commonly exhibits 1 root (98%) (21). Two roots (1.8%) and 3 roots (0.1%) are rare. Regarding the internal canal morphology, a single canal is present in about 75.8% of teeth, and 2 or more canals exist in 24.2% of the teeth. The second mandibular premolar is usually single rooted (99.6%). The incidence of 2 (0.3%) or more roots (0.1%) seems to be negligible, whereas 2 or more root canals occur in nearly 10% of the teeth (22). The aim of this study was to investigate the root anatomy and the root canal morphology in German patients seeking surgical or implant-related dental care using CBCT data.

Materials and Methods

Sample Selection

The sample size was calculated using a sample size calculator. The German population is about 80 million people. With a margin of error of 5% and a confidence level of 99%, the recommended sample size was 664. Thus, out of more than 1000 CBCT scans, a total of 700 full-size scans (Planmeca Promax 3D; Planmeca, Helsinki, Finland) with a field of volume of 8 × 8 cm and a voxel size ≤200 μm showing both the mandible and maxilla including the root apices of all teeth were retrospectively selected and randomly analyzed. The selection criterion for the included CBCT scans was to ensure a balanced distribution of left versus right premolars. The CBCT scans were obtained from the Dental Clinic of Bochum, Bochum, Germany, and were taken from June 2007 to November 2012. The radiographic examination was not related to this study; most patients underwent surgical procedures or guided implantation. All data were anonymized; only the origin of the patients, sex, and age at the time of radiation exposure were known to ensure that all patients were of German origin.

To assess the number of roots and the root canal anatomy of the mandibular and maxillary premolars, the multiplanar reconstruction view of the manufacturer's software viewer (Planmeca Romexis) with its axial, coronal, and sagittal plane was chosen, and the teeth were analyzed by scrolling through the different planes (Fig. 1). The tooth and plane were oriented by clicking and dragging the coronal and sagittal cursor. The axial plane was dragged from the crown to the root apex to observe the morphology of the roots and canals of the selected teeth. If needed, the contrast was adjusted, and the magnifying tool was used.

Two endodontists with requisite qualification and competence in CBCT diagnostics evaluated the sample simultaneously and separately to achieve conformity. If disagreement existed, a joint meeting of all authors was made until a consensus was reached. A joint meeting was necessary in 55 of 700 cases. Calibration of the 2 examiners was ensured because both had board-certified skills in CBCT imaging. To avoid any potential sources of bias, all scans were numbered from 1 to 700, and this was the only information available for both examiners.

The number of roots detected from the axial plane of CBCT images was classified as follows (23):

1. A single-rooted tooth: the tooth has a clear single root, including those having 2 independent canals mimicking having 2 roots but still fused
2. A multiple-rooted tooth
   a. A tooth with bifurcated roots (regardless of partial or complete) = a 2-rooted tooth
   b. A tooth with 3 completely independent roots from the chamber floor or teeth presenting bifurcations at any position along the roots = a 3-rooted tooth

Canal Configuration

The classification according to the criteria of Vertucci et al (2) was used. Tooth position, number of roots, canal configuration, number of canals, and apical foramina per root were recorded.

Data were statistically analyzed using the Fisher exact test (the prevalence of roots and root canals). StatView 5.0.1 (SAS Institute Inc, Cary, NC) software was used for statistical analyses. For statistical analyses regarding the differences in sex distribution or the location of the teeth (left vs right), the chi-square test was performed. *P* values <.05 were considered significant.

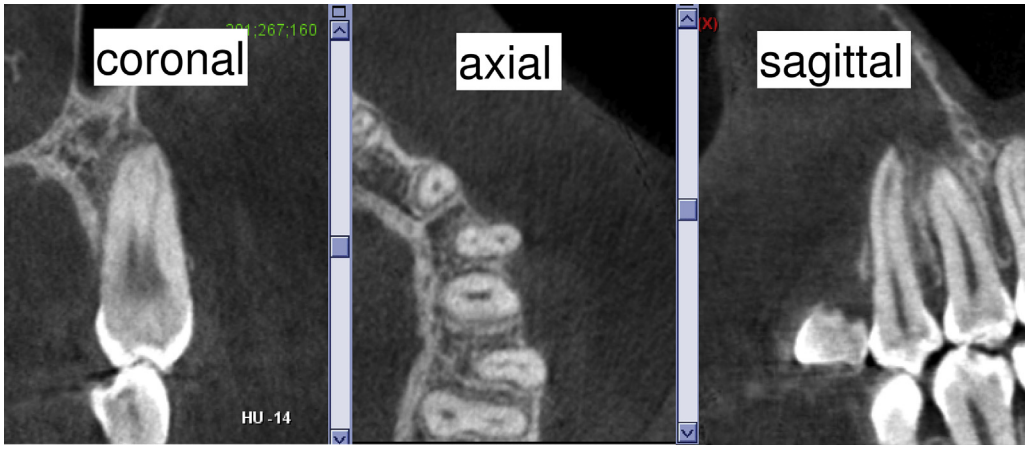

Figure 1. Multiplanar reconstruction view (coronal, axial, and sagittal) of a maxillary first molar. Vertucci classification IV (2).