Topographic analysis of the maxillary premolars relative to the maxillary sinus and the alveolar bone using cone beam computed tomography

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Objective. The purpose of the present study was to elucidate the anatomic characteristics of the maxillary premolars for the planning of dental treatment using cone beam computed tomography (CBCT).

Study Design. CBCT images were obtained for 150 maxillary premolars in 68 patients. The internal angle formed by the long axis of the maxillary premolars and the long axis of the alveolar bone was evaluated on the cross-sectional images. The vertical relationships between the maxillary premolars and the maxillary sinus were classified into 5 categories. The bone width and internal angle were compared among the images classified into the 5 categories.

Results. The internal angle was $25.5 \pm 6.9°$ at the maxillary first premolars. The incidence of Type I in the maxillary first premolars was 46.7%. In the maxillary second premolars, the incidence of Type I (14.7%) was significantly lower than the total incidence of Types II, III, IV, and V (85.3%). Type I had the significantly largest internal angle ($28.0 \pm 7.7°$) among all types for the maxillary first premolars.

Conclusion. When considering dental treatment in the maxillary premolars, one should observe the inclination of the maxillary premolars to the alveolar bone as well as the position of the inferior wall of the maxillary sinus. (Oral Surg Oral Med Oral Pathol Oral Radiol 2017;123:606-612)

Many clinicians plan prosthetic and endodontic treatments and surgical procedures after assessing the morphologic characteristics of tooth length and root position and the relationship between the maxillary teeth and the alveolar bone.[1-11] When considering the topographic morphology at the maxillary teeth and the alveolar bone, the maxillary premolars have complex characteristics because of the transition from the curved alveolar bone in the anterior maxilla to the upright alveolar bone in the posterior maxilla, and the proximity to the maxillary sinus. Therefore, knowledge of the internal angle of the maxillary premolars is important for accurate crown preparations and successful endodontic treatment. Also, the relationship between the premolar roots and the maxillary sinus should be known to decrease the risk of complications, such as unintended extension of dental implants into the maxillary sinus and periapical perforation during root canal treatment, which can cause maxillary sinusitis. In addition, knowledge of topography of the maxillary sinus is important for understanding the path of a dental infection in endodontic and surgical procedures and the orthodontic movement of teeth.[12,13] However, few studies have investigated the classification of the relationship between the maxillary premolars and the maxillary sinus using CBCT.

Statement of Clinical Relevance

Many clinicians have established dental treatment plans after assessing the morphologic characteristics of the tooth length and root position and the relationship between the maxillary teeth and the alveolar bone for successful prosthetic and endodontic treatments and surgical procedures.

The morphologic characteristics of the maxillary teeth have been routinely evaluated on 2-dimensional images using panoramic and intraoral radiography.[14] However, it has been recommended that 3-dimensional computed tomography (3-D CT) imaging be used to investigate the root structure or the relationship between the maxillary teeth and the alveolar bone for prosthodontic and endodontic treatment, and to select an appropriate implant design and an ideal position and direction for immediate implant placement.[15-17] A few studies have assessed the morphologic characteristics of the maxillary teeth using cone beam computed tomography (CBCT). Sherrard et al.[3] reported that CBCT scans are at least as accurate and reliable as periapical radiographs for the determination of tooth length and root length. In our previous investigation, we found that CBCT evaluations of the angle of the long axis to the alveolar bone and the position of the inferior wall of the maxillary sinus are important for accurate insertion of dental implants in the maxillary premolar and molar regions.[11] This knowledge is necessary to determine the proper insertion angle of a dental implant and increase the likelihood of long-term integration.[11,18]

Tyndall et al.[19] wrote that multiplanar reconstructions of conventional multidetector CT scans can be reconstructed in various image thicknesses and in any planar orientation, including but not limited to axial, sagittal, and coronal planes. Although the benefits of conventional CT imaging for dental implant treatment are well known, it is relatively expensive and usually only available in hospitals and medical imaging centers, and difficulties in its interpretation have limited its use. CBCT has been developed and used for patients requiring surgical facial reconstruction, orthognathic surgery, and tooth extractions.[6-8,13,20] CBCT scans are desirable for assessment of the morphologic characteristics of teeth and alveolar bone, and are usually achieved with substantially lower effective doses than conventional CT.[21-23] Topographic analysis performed on CBCT images is an effective method for well tolerated and reliable dental treatment.[11,18,24] We are currently in, or approaching, a time when CBCT scans are recommended for many patients before surgical extractions, orthognathic surgery, and other well-known indications for the technique. However, the expensive apparatus required for CBCT is not common in dental offices. Therefore, clinical assessments of the morphologic characteristics of alveolar bone and teeth using CBCT are infrequently encountered. We suggest that if the morphologic characteristics of the maxillary premolars and the alveolar bone have been identified by CBCT imaging, we may be able to provide useful information for clinicians who cannot use CBCT, thus leading to successful treatment outcomes.

The purpose of this study was to examine CBCT images to clarify the morphologic characteristics of the maxillary premolars and the alveolar bone, and to identify the relationship between the maxillary premolars and the maxillary sinus.

MATERIALS AND METHODS

CBCT images of 150 maxillary first and second premolars were obtained for 75 sides in 68 patients. The patients included 14 males and 54 females with a mean age of 52.1 years (range, 23-80 years). All teeth were present without any malformations or bony defects in the maxilla. Maxillary premolar measurements were made on available CBCT images taken for the purpose of dental implant treatment for the mandibular premolars and molars. This study was approved by the Ethics Committee of Kagoshima University Graduate School of Medical and Dental Sciences (20-106). All patients provided written informed consent before participating in the study. Our research was conducted in full accordance with the World Medical Association Declaration of Helsinki.

All patients were scanned by CBCT (3DX Multi-Image Micro CT/3D; Accuitomo, Morita, Japan). None of the patients had constitutional diseases of the bone or skeletal dysplasia. The acquisition parameters for the CBCT images were 60-80 kV and 1-10 mA, with slice thickness of 0.125 mm and exposure time of 17.5 s. The voxel size in the reconstruction was 0.125 mm. The acquisitions were examined with multiplanar reconstructions (cross-sectional, axial-sectional, and panoramic-sectional) using i-View software (J Morita Corporation, Osaka, Japan). The measurements were accomplished on the cross-sectional 3-D CT images (b) reconstructed by the medial line of the root crown at the maxillary premolars on the axial-sectional 3-D CT images (a) and the panoramic-sectional 3-D CT images (c) using i-View software in accordance with the method of Yoshimine et al.[11] (Figure 1). A single examiner with education and experience in CBCT measured the bone width of the alveolar bone and the internal angle at the maxillary premolars and classified the positional relationships between the maxillary premolars and the inferior wall of the maxillary sinus into 5 categories on the cross-sectional 3-D CT images of CBCT. The bone width of the alveolar bone and the internal angle, classified into 5 categories, were used for statistical analysis.

Measurements of the bone width of the alveolar bone and the internal angle of the maxillary premolars on the cross-sectional images

The bone width of the alveolar ridge between the buccal and palatal cortices at the sites of the maxillary premolars (L) was measured on the cross-sectional CBCT images.