Measurement of Cortical Bone Thickness in Adults by Cone-beam Computerized Tomography for Orthodontic Miniscrews Placement

Hong ZHAO (赵弘) 2, Xiao-ming GU (顾晓明) 2, Hong-chen LIU (刘洪臣) 1#, Zhao-wu Wang (王照五) 1, Chun-lei XUN (寻春雷) 3

1Institute of Stomatology, Division of Clinical Surgery, Chinese PLA General Hospital, Beijing 100853, China
2Center of Stomatology, General Hospital of Chinese Peoples Armed Police Forces, Beijing 100039, China
3Department of Orthodontics, Peking University School and Hospital of Stomatology, Beijing 100081, China

© Huazhong University of Science and Technology and Springer-Verlag Berlin Heidelberg 2013

Summary: The purpose of this study was to investigate the cortical bone thickness of the inter-dental area of both jaws for orthodontic miniscrew placement. The cone-beam computerized tomography images of 32 non-orthodontic adults with normal occlusion were taken to measure the cortical bone thickness in both jaws. One-way analysis of variance (ANOVA) was used to analyze the differences in cortical bone thickness. Buccal cortical bone in the mandible was thicker than that in the maxilla. In the maxilla, cortical bone thickness was thicker in the buccal side than in the palatal side. Buccal cortical bone thickness in the mandible was thickest at the site distal to the first molar, and in the maxilla it was thickest at the site mesial to the first molar, while in the palatal side of maxilla it was thickest at the site mesial to the second premolar. The changing pattern of cortical bone thickness varies at different sites. In the buccal side of maxilla, the thinnest cortical bone thickness was found to be at 4 mm level from the alveolar crest, while the thickest was at 10 mm level (except for the site mesial to the first premolar). The buccal cortical bone thickness at the sites mesial or distal to the first molar in the mandible and palatal cortical bone thickness of maxilla tended to increase with increasing distance from the alveolar bone.

Key words: miniscrew; cortical bone thickness; bone quality

Anchorage control, a major challenge faced by orthodontists in their clinical practice, decides the success of orthodontic treatments. Traditional means of anchorage control depend very much on patient compliance, and the dependency on patient compliance greatly increases the risks of failure. Miniscrews, as an alternative to traditional anchorage means, can be used effectively with minimal patient compliance. Compared with absolute skeletal anchorage like dental implants, miniplates, and onplants, miniscrews show their great advantages in the following aspects: small size, easy placement and removal, low cost, minimal anatomic limitation for placement, less discomfort after surgery, and immediate loading or early loading with the mechanical interdigitation at bone-miniscrew interface[14].

Miniscrews, as means to provide absolute skeletal anchorage, have expended the scope of traditional orthodontics. They can be used in anterior retraction, molar intrusion to correct an open-bite, controlling vertical dimension, molar distalization, molar protraction, and canting correction, or even moving the entire dentition in the same direction[5-9]. Consequently, many implant sites[5-7, 10], such as hard palate, interradicular spaces of the maxilla and mandible, and retromolar area in the mandible have been proposed and used for each aim. However, miniscrews may loosen during orthodontic treatment, therefore, the stability of the miniscrew is essential to enhance its success rate for orthodontic anchorage[11-14].

Recent studies show that factors related to the stability of miniscrews included[11-15]: the cortical bone quality and quantity, soft tissue inflammation around the miniscrew, interradicular space, the design of the miniscrew as well as particular insertion modalities. The cortical bone thickness is the decisive factor in considering miniscrew anchorage, while the Young’s modulus of the trabecular bone is only influential when cortical bone is inadequately thick[15-18]. Motoyoshi recommended that a cortical bone thickness of 1.0 mm or more was the critical value of cortical bone thickness for the success of miniscrews implantation[19, 20]. Therefore, the cortical bone thickness is paramount for the stability of miniscrews[18-22] (fig. 1). Placing miniscrews in sites of favorable cortical bone thickness would guarantee better initial stability and long-term success.

Fig. 1 Skeletal anchorage with a miniscrew

A few studies were conducted to investigate the cor-
tical bone thickness for miniscrew implantation for orthodontic anchorage. Kim et al.[23] measured buccal-palatal cross-sectional samples from interdental areas of posterior teeth and midpalatal suture areas of 23 adult Korean cadavers, but nevertheless they just evaluated one side of the maxilla and left cortical bone thicknesses of the mandible unmeasured. Deguchi et al.[24] measured the cortical bone thickness in 10 patients with malocclusions using computed tomography (CT) images in various sites, and the cortical bone thickness was measured at only two levels (occlusal and apex). Sebastian et al.[25] investigated the buccal cortical bone thickness of each interdental site at 2, 4, and 6 mm from the alveolar crest, using cone-beam computed tomography (CBCT) scans of 30 adult dry skulls. However, the palatal sites in the posterior maxillary alveolar bone in which miniscrews were usually placed were not investigated in the study, and the measured value might be underestimated due to shrinkage in dry skulls. As far as the previous studies show, the buccal cortical bone thickness of mandible and palatal cortical bone thickness of maxillary alveolar bone have seldom been evaluated in nonorthodontic subjects with normal occlusion.

Accordingly, the objective of this study was to investigate the cortical bone thickness at the buccal and palatal sides of maxillary alveolar bone, the buccal side of the mandibular alveolar bone, where miniscrews are usually implanted. The findings of the investigation will provide a guideline for correct planning and placement of miniscrews.

1 MATERIALS AND METHODS

1.1 Study Sample

The study subjects consisted of 32 adults (16 males and 16 females), with a mean age of 30.1 years (ranging from 21 to 44 years). Approval of this study was obtained from the PLA General Hospital Independent Ethics Committee. All the subjects were informed of the study procedures and informed consent was signed before recruitment.

The inclusion criteria for study subjects included: (1) subjects with average mandible plane angles; (2) Class I molar relationship, normal overjet and overbite; (3) no periodontal disease with no alveolar bone loss; (4) no missing teeth except for the third molars; (5) no orthodontic history; (6) no severe skeletal discrepancies, no asymmetric occlusions; (7) no severe crowding.

1.2 Study Methods

The oral and maxillofacial of the subjects were imaged with CBCT (QR-DVT9000 NewTom, Italy) at 110 kVp, 3.0 Ma, scanning time of 77 s, and slice thickness of 1 mm.

The original images of the lateral position were viewed through mini-panes. The horizontal marking line was reconstructed to be in parallel position to the occlusion plane. While the reconstruction of the maxilla was determined, the exposed area was located from the area above the occlusal plane to the base of the nose (fig. 2A). While the reconstruction of the mandible was determined, the exposed area was located at the area below the occlusal plane towards the border of mandible (fig. 2B).

In the reconstructed axial horizontal images, the two-dimensional orientation of the interdental slice was chosen, which showed every tooth clearly and teeth’s space wide. Just above the level of the alveolar crest (fig. 3), a cortical bone was to be measured and reconstructed the second time on this slice. The images were enlarged appropriately for visual gray-white discrimination (fig. 4). The white area was cortical bone, and the grey was the trabecular bone. Cortical bone with clear edge was selected to measure its thickness.

Two weeks after the first measurement the same measuring process was repeated by the same observer in 4 study subjects. After another two weeks, duplicate measurements were carried out on one of every 10 study subjects.

As it was convenient for description, each measurement area was coded with a number (fig. 5). Beginning in the maxilla right section, the measurement site of the mesial to the second molar at the right upper section was coded as number 1. And the coding followed this direction through the anterior in the maxilla, the left side