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Cortical bone thickness at common miniscrew implant placement sites

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Introduction: The purpose of this study was to assess age, sex, and regional differences in the cortical bone thickness of commonly used maxillary and mandibular miniscrew implant placement sites. **Methods:** Cone-beam computed tomography images, taken at 0.39-mm voxel size, of 52 patients, including 26 adolescents (13 girls, ages 11-13; 13 boys, ages 14-16) and 26 adults (13 men and 13 women, ages 20-45), were evaluated. The cone-beam computed tomography data were imported into 3-dimensional software (version 10.5, Dolphin Imaging Systems, Chatsworth, Calif); standardized orientations were used to measure cortical bone thickness at 16 sites representing the following regions: 3 paramedian palate sites, 1 infrazygomatic crest site, 4 buccal interradicular sites of the mandible, and 4 buccal and 4 lingual interradicular sites in the maxilla. **Results:** Multivariate analysis of variance (MANOVA) showed no significant differences in cortical bone thickness between the sexes. There were significant ($P < 0.05$) differences between adolescents and adults, with adult cortices significantly thicker in all areas except the infrazygomatic crest, the mandibular buccal first molar-second molar site, and the posterior palate site. Cortical bone was thicker in the posterior than in the anterior mandibular sites. In the adults, interradicular bone in the maxillary first premolar-second premolar, and second premolar-first molar sites was thicker than bone at the lateral incisor-canine and first molar-second molar sites. Anterior paramedian palatal bone was significantly thicker than bone located more posteriorly. The mandibular buccal and infrazygomatic crest regions had the thickest cortical bone; differences between the maxillary buccal, the maxillary lingual, and the palatal regions were small. **Conclusions:** Maxillary and mandibular cortical bones at commonly used miniscrew implant placement sites are thicker in adults than in adolescents. There are also differences in cortical bone thickness between and within regions of the jaws that must be considered when placing miniscrew implants. (Am J Orthod Dentofacial Orthop 2011;139:495-503)

Miniscrew implants (MSIs), used by approximately 80% of orthodontists, make treatments better for approximately 78% of the orthodontists recently surveyed.[1] MSIs are commonly placed into the maxillary and mandibular buccal alveolar bones to improve anchorage, to increase the horizontal component of applied force during space closure, and for posterior intrusion in open-bite patients.[2,3] MSIs have been placed into the infrazygomatic crest for space closure, posterior intrusion, and distalization.[4-6] They have also been placed in the palatal alveolar bone and the paramedian palate.[7,8]

The loosening and failure of MSIs are major limitations for their use. Important risk factors for MSI failure include placement in the mandible, placement in thin (<1 mm) cortical bone, and placement torque values outside the 5 to 10 Ncm range.[9-12] According to Costa et al[13] and Miyawaki et al,[14] cortical bone quality and quantity are major factors associated with primary stability of MSIs, probably because it is achieved by mechanical retention rather than osseointegration. Wilmes et al[15] found that cortical bone thickness has a strong effect on the primary stability of MSIs. Placement torque and pullout strength of MSIs have also been correlated with cortical bone thickness.[16,17] Clinically, MSI failures have been reported to result from thin cortical bone.[9,14,15] Miyamoto et al suggested that cortical bone thickness plays a greater role in determining stability than implant length.[18]

Although well-controlled studies have not been performed, it appears that MSIs placed in younger or

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adolescent patients tend to fail more often than those placed in adults. Chen et al[10] concluded that placing MSIs in younger patients was a primary risk factor associated with their failure. Park et al,[19] who placed MSIs in subjects from 11 to 28 years of age, observed failures only in patients younger than 14 years. Garfinkle et al[2] reported a much lower overall MSI success rate (70.3%) in adolescent patients than did other studies evaluating adults. Motoyoshi et al[20] reported their lowest success rate (63.8%) for adolescent patients. Because age differences in cortical bone thickness have not been systematically studied, it is unclear whether cortical thickness could explain the differences in the failures observed.

It is also important for the clinician placing MSIs to be aware of any differences in cortical bone thickness between and within regions of the jaws. Thicker cortical bone has been reported for the mandible than the maxilla.[21-24] There also appear to be differences in each jaw, with the thickest cortical bone in the molar region, followed by the premolar and incisor regions, respectively.[21,22,25] Bone in the mandibular buccal region has also been reported to be thicker than bone in the mandibular lingual region.[22] Although specific sites and regions have been evaluated, there is no comprehensive assessment of cortical bone thickness at common MSI placement sites of both the maxilla and the mandible.

The purpose of this study was to examine the cortical bone thickness at common sites of MSI placement in patients before treatment. The hypotheses were that there are no differences in cortical bone thickness between adolescents and adults, between the sexes, between sites within regions, or between regions of the maxilla and the mandible.

MATERIAL AND METHODS

Pretreatment cone-beam computed tomography (CBCT) scans (CB MercuRay, Hitachi International, Tokyo, Japan), taken in the orthodontic department of University of Nevada, Las Vegas., were evaluated to identify 52 consecutive patients, including 2 groups comprising 26 adolescents (13 girls, 11-13 years of age; 13 boys, 14-16 years of age) and 26 adults (13 men and 13 women, 20-45 years of age). The scans were selected according to the age requirements, a 0.39-mm voxel size, and the following exclusion criteria: (1) missing or unerupted permanent teeth in the quadrant measured, (2) periapical or periradicular pathologies or radiolucencies of either periodontal or endodontic origin, (3) a significant medical or dental history (eg, use of bisphosphonates or bone-altering medications, or diseases), (4) severe facial or dental asymmetries, and (5) vertical or horizontal periodontal bone loss.

The CBCT scans were imported into 3-dimensional software (version 10.5, Dolphin Imaging Systems, Chatsworth, Calif) for analysis as digital imaging and communications in medicine (DICOM) multi-files. The thickness of the buccal cortical plates of the maxilla and the mandible were measured in the interradicular areas between the (1) lateral incisor and canine (2-3), (2) first and second premolars (4-5), (3) second premolar and first molar (5-6), and (4) first and second molars (6-7). The lingual cortical plate of the maxilla was measured at the same 4 locations. The lingual cortical plate in the mandible was not measured because of its limited use for MSI placement. The interradicular measurements were made 4 mm apical to the alveolar crest, which is approximately at the level of the mucogingival junction.[26-29] All interradicular sites selected for measurement have been previously used for MSI placement.[1,6,7,13,28,30-32]

The infrazygomatic crest of the maxilla was also measured. The cortical thickness at the level of the mesiobuccal cusp of the maxillary first molar was selected based on the work of Liou et al.[33]

The paramedian palate was measured 3, 6, and 9 mm dorsal and 3 mm lateral to the incisive foramen. The paramedian palate sites were chosen based on a study of palatal bone thickness, which showed that these areas have sufficient bone to avoid nasal perforation on MSI placement.[30]

For each patient, either the right or the left quadrant of the maxilla and the mandible was randomly chosen for the measurements. Only 1 side was measured because it was previously shown that there are no differences in cortical thickness between sides of the jaws.[22,24,30]

Before measurement, each site was oriented in all 3 planes of space. For the measurements made in the posterior interradicular areas of the maxilla and mandible, the sagittal slice was used to locate the interradicular area of interest (Fig 1, *A*). The slice was then oriented so that the vertical reference line bisected the interradicular space and was parallel to the long axes of the roots. The axial slice was then used to ensure that the horizontal reference line traversed the thinnest area of cortical bone while bisecting the interradicular area (Fig 1, *B*). The vertical level of the measurement was established 4 mm apical to the crest of the alveolar bone by using the coronal slice. This was accomplished by moving the horizontal reference line based on the millimeter rule at the border of the frame. By using the coronal slice, the final measurements were made through the thinnest portion of the cortical bone where the horizontal reference line contacted the endosteal surface (Fig 1, *C*).

For the anterior maxilla and mandible, the coronal slice was used to locate the interradicular area, with the vertical reference line oriented parallel to the adjacent roots and bisecting the interradicular space (Fig 2, *A*). The axial slice was then used to orient the vertical reference line through the thinnest area of cortical