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Research Paper
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Cortical bone thickness of the mandibular canal and implications for bilateral sagittal split osteotomy: a cadaveric study

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Abstract. Preoperative delineation of the mandibular canal and surrounding cortical bone thickness is mandatory prior to bilateral sagittal split osteotomy (BSSO). The cortical bone thickness of 101 cadaveric mandibles was measured to define the mandibular canal. The mandibles were cut at the anterior ramus, at the third, second, and first molar, and at the premolar. The cortical bone thickness was measured between the mandibular canal and inferior border, buccal cortex, and lingual cortex at each cutting point. No difference was found between the right and left sides of the mandible, or between males and females, with one exception: males were found to have thicker inferior cortical bone at the premolar site than females. The implications for BSSO are: (1) for sagittal bone cutting, the maximum cutting depth of the buccal cortex at the ramus is 4.5 mm, at the second and third molars is 6.5 mm, and at the first molar is 5 mm; (2) for vertical bone cutting at the first molar, the maximum cutting depth from the inferior border is 7.5 mm. The measurement of cortical bone thickness from cadaveric mandibles provides useful preoperative information and confirms the results of computed tomography.

Key words: cortical bone thickness; mandibular canal; bilateral sagittal split osteotomy; cadaveric study.

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The mandibular canal is the most important anatomical structure for bilateral sagittal split osteotomy (BSSO), an orthognathic surgical procedure performed to correct deformity of the face and occlusion. The BSSO was first performed in 1942 and was improved in 1957.[1] The mandibular canal carries the inferior alveolar nerve (IAN), which supplies the mandible, lower teeth, lower lip, and chin. It begins at the mandibular foramen at the ramus of the mandible and ends at the mental foramen. To avoid injury to the IAN and blood vessels during the BSSO procedure, the surgeon must have

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correct preoperative information on the cortical bone thickness, i.e. the thickness of the cortex bone measured from the mandibular canal to the inferior and buccal borders of the mandible.

The morphology of the mandibular canal depends on the dental status, age, and ethnicity.[2] The mandibular canal in the lower molar region is located near the apex of the second molars,[3] inferior to the third molars, or diverts near the third molars.[4,5] For the first molars, the cortical bone thickness depends on age and sex. Also, buccal thickness is greater in males than in females.[6,7] Patients aged 16–25 years and those over 55 years old have a thinner cortical bone thickness than those at other ages.[7] Also, the distal root of the lower first molars is located closer to the mandibular canal than the mesial root.[8] The cross-section of the mandibular canal can have one of three shapes: round/oval, teardrop, and dumbbell.[9] The shape and discontinuity of the mandibular canal are associated with IAN injury.[10] The diameter of the mandibular canal at the ramus varies between 2.3 mm and 2.7 mm.[11]

The sagittal bone cutting during BSSO considers the cortical bone thickness on the buccal side, whereas the vertical bone cutting during BSSO considers both the buccal and inferior sides. In earlier studies, the cortical bone thickness around the mandibular canal was measured in cross-sections of cadaveric mandibles using a caliper.[3,12] In later studies, the cortical bone thickness measurements were made using computed tomography (CT),[1,13,14] spiral CT,[15] cone beam CT (CBCT),[4,16,17] and magnetic resonance imaging (MRI).[18] The buccal cortical bone thickness is related to the dentofacial relationship[17] and masticatory function.[19] Recently, the finite element method has been used to simulate internal fixation techniques for the BSSO.[20] A good recommendation for the cortical bone thickness to be left around the mandibular canal after bone cutting in BSSO is at least 1 mm.[2]

Previous cadaveric studies have not shown details of the cortical bone thickness and the mandibular canal from the ramus to the mental foramen. They have been specific to particular lower molars. The objectives of the present study were: (1) to measure the cortical bone thickness around the mandibular canal of 101 dry Thai cadavers by cutting five cross-sections from each mandible, and (2) to recommend the bone cutting depth for BSSO. As such, this research identifies and demonstrates a novel approach. These sections were located at the ramus, third molar, second molar, first molar, and premolar. From the findings of this study on cortical bone thickness, recommended bone cutting depth values for use during BSSO are provided (as measured from the inferior and buccal borders to the mandibular canal), with the aim of avoiding injury to the IAN.

Materials and methods

The sample included 101 dry Thai cadaveric mandibles, which were obtained from the Departments of Anatomy of Naresuan University, Phitsanulok and Khon Kaen University, Khon Kaen, Thailand. Fifty-one were right-side mandibles and 50 were left-side mandibles. Seventy-two were from male subjects and 29 were from female subjects; the age at death of the samples ranged from 29 to 95 years (average 68 years, standard deviation 17.6 years). The mandibular canal rims of a few samples were damaged following cutting. The cortical bone thickness could not be measured in these samples and so they were excluded from the study. Lines were marked on the mandibles to guide bone cutting (Fig. 1). Most samples were missing the molars and premolars, so the lines were started at the anterior border of the mental foramen and were continued to the anterior border of the ramus at 1-cm intervals, with the first line located at premolar (PM), the second line at first molar (M1), the third line at second molar (M2), the fourth line at third molar (M3), and the final line at ramus (R). A No. 16 carbide taper fissure bur was then used to cut the mandible into slices. The cutting surface was normal to the inferior border of the mandible.

As illustrated in Fig. 2, the cortical bone thickness was measured in three directions: (1) from the inferior border of the mandible to the mandibular canal floor, labelled 'IM', (2) from the buccal cortex of the mandible to the lateral wall of the mandibular canal, labelled 'BM', and (3) from the lingual cortex of the mandible to the medial wall of the mandibular canal, labelled 'LM'. Figure 3 shows examples of the five cut surfaces with the three straight lines, IM, BM, and LM, marked for measurement. An automatic digital Vernier caliper was used to measure the lengths of IM, BM, and LM.

The cortical bone thickness along the lines IM, BM, and LM was measured in triplicate by two well-trained investigators. The cortical bone thickness values recorded by the two investigators were compared (inter- and intra-examiner reliability) using Pearson's correlation; the inter-examiner agreement was $r > 0.982$ and intra-examiner agreement was

Fig. 1. Cross-sectional lines on a dry cadaveric mandible for cutting at 1-cm intervals. These lines run from the anterior border of the mental foramen to the anterior ramus of the mandible.

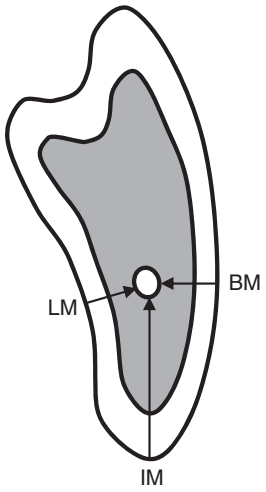

Fig. 2. Terminology used in the measurement of the cortical bone thickness on the left side of the mandible. IM: from the inferior border of the mandible to the floor of the mandibular canal. BM: from the buccal cortex of the mandible to the lateral wall of the mandibular canal. LM: from the lingual cortex of the mandible to the medial wall of the mandibular canal. Not to scale.

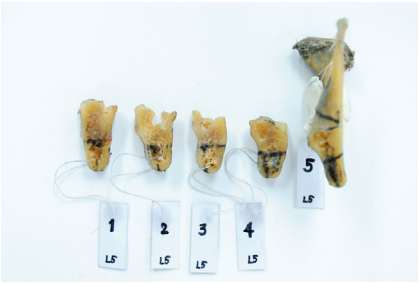

Fig. 3. The five cross-sections after bone cutting. Slice 5 is at R (ramus), slice 4 is at M3 (third molar), slice 3 is at M2 (second molar), slice 2 is at M1 (first molar), and slice 1 is at PM (premolar). The reference point for locating the mandibular canal is located at the anterior border of the individual teeth.

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