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Mandibular Anatomy Related to Sagittal Split Ramus Osteotomy in Koreans

Hee-Jin Kim[1], Hye-Yeon Lee[2], In-Hyuk Chung[2], In-Ho Cha[3], and Choong-Kook Yi[3]

Sagittal split ramus osteotomy (SSRO) is one of the surgical techniques used to correct mandibular deformities. In order to prevent many surgical anatomical problems, we observed the anatomical structures related to SSRO. In dry mandibles of Koreans, lingular tips were located somewhat posteriorly and superiorly on the mandibular ramus. On the coronal sections of mandible, the mean cortical width of facial cortex was increased toward the ramus region while the lingual cortex was thinnest in the ramus region. On the same sections, all the fusion points of the buccal and lingual cortical plate were located above the mandibular lingula and beneath the mandibular notch. So, performing the SSRO on Koreans, medial horizontal osteotomy should be done through the superior aspect of the mandibular lingula. The cut line is extended 5-8 mm posterior to the mandibular lingula to preserve sufficient cortical width to strengthen the involved osseous segments and reduce possible surgical complications.

Key Words: Mandibular ramus, mandibular lingula, cortical plate, SSRO, Koreans

Mandibular prognathism and retrognathism are common dentofacial deformities caused by the overgrowth and undergrowth of the jaw, respectively (Archer, 1975). These congenital malformations often occur in Asians, and particularly mandibular prognathism is more prevalent in Koreans than in any other ethnic groups (Suhr *et al.* 1984; Kang and Yoo, 1991). Nowadays, in order to improve these deformities, sagittal split ramus osteotomy (SSRO) is frequently performed (Trauner and Obwegeser, 1957) in Korea.

Indications and advantages of the SSRO have been well established (Bell and Schendel, 1977). Nevertheless, many complications including fracture of the proximal or distal bony segments have been encountered during or after SSRO (Behrman, 1972; McNeil, 1973; Ive *et al.* 1977). Especially when performing the medial horizontal osteotomy of the mandibular ramus during SSRO, unfavorable fractures can occur due to fusion of the medial lateral cortical plates; cancellous bone between the two plates allows a plane in which a favorable fracture can take place. Furthermore, in cases of thin cortex and high mandibular angles, troublesome complications will also follow SSRO. To minimize these problems, modifications of the surgical technique

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Department of Oral Biology, Division of Anatomy, College of Dentistry[1] and Department of Anatomy, College of Medicine[2] and Department of Oral & Maxillofacial Surgery, College of Dentistry[3], Yonsei University
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Address reprint request to Dr. H.J. Kim, Department of Oral Biology, Division of Anatomy, College of Dentistry, Yonsei University, 134 Shinchon-Dong, Seodaemoon-Ku, Seoul 120-752, Korea

have been reported by many clinicians (DalPont, 1961; Hunsuck, 1968; Epker, 1977; Jeter *et al.* 1984; Rajchel *et al.* 1986; Wolford *et al.* 1987; Smith *et al.* 1991). Since previous studies have been based on clinical experience, however, only limited anatomical data have been used in SSRO (Rajchel *et al.* 1986; Wolford *et al.* 1987; Smith *et al.* 1991).

On the basis of the anthropological survey of mandibles, metric characteristics of the mandible vary among races. Furthermore, Korean mandibular rami are the largest among Asians, but smaller than Caucasians (Lee, 1961). So, it is unreasonable to apply other foreign data to Koreans.

The aims of this study are to determine the location of the mandibular lingula related to the surrounding structures and to provide meaningful information to oral and maxillofacial surgeons and clinicians by observing the mean cortical width of the mandibular cortex and the point where the buccal and lingual cortical plates are fused on the sectioned Korean mandibular rami and to compare these results with those of other races.

MATERIALS AND METHODS

This study was conducted on 242 dry mandibles of Koreans of unknown sex and age. The specimens consisted of 162 dentulous, and 58 edentulous adult mandibles, as well as 22 children's mandibles with mixed dentition.

Prior to measuring the location of the mandibular lingula, a line was first drawn from the anterior border to the posterior border of the mandibular ramus through the lingular tip. Then another line, perpendicular to the previous line, was drawn from the portion of the mandibular notch to the antegonial notch of the mandibular inferior border through the lingular tip. After this, we measured the maximal width of the ramus through the mandibular lingula and the distance between the mandibular anterior border and the mandibular lingular tip on the same horizontal line. Also, the ramus height from the deepest point of the mandibular notch to the antegonial notch and the distance between the mandibular notch and the mandibular lingula were measured on the same vertical line by using Vernier's calipers, which are capable of measuring to the nearest 0.01 mm (Fig. 1). After measurements, the ratio was calculated for each length. The relationship of the mandibular tooth and mandibular lingula was obtained by measuring the horizontal distance from the distal side of the mandibular second molar and

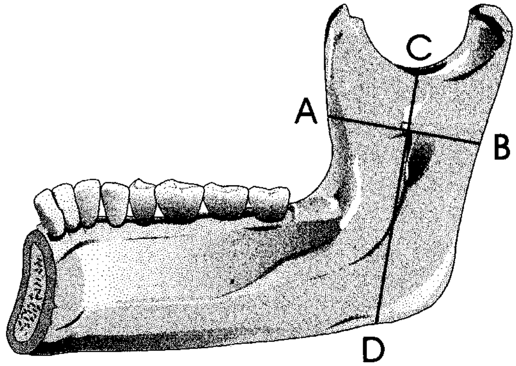

Fig. 1. Anatomical landmarks for measuring the position of the mandibular lingula. A: anterior border of the mandibular ramus, B: posterior border of the mandibular ramus, C: the portion of the mandibular notch, D: antegonial notch of the inferior border of the mandible.

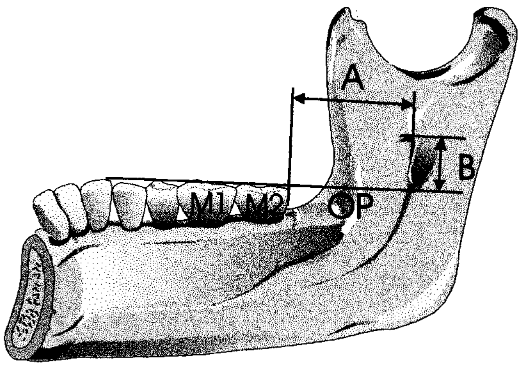

Fig. 2. Measurements of the location of the mandibular lingula in relation to the mandibular teeth. A: horizontal distance from distal side of the mandibular second molar to the tip of the mandibular lingula, B: vertical distance from the occlusal plane to the tip of the mandibular lingula (M1: mandibular 1st molar, M2: mandibular 2nd molar, OP: occlusal plane).

the vertical distance from the occlusal plane to the mandibular lingular tip (Fig. 2).

Fifty dentulous adult hemimandibles were sectioned coronally to observe the morphology of the ramus cortex using a bone trimmer (Moruta Co., Tokyo, Japan, Model No 89-04-591) with a 20 cm-diameter diamond disk. Sections were made in the region of the mandibular 1st molar, 2nd molar and 3rd molar (or ascending ramus region) and the lines of sections were positioned at the root apex parallel to the longitudinal axis of the tooth. Coronal sections in the mandibular ramus were made into four parts perpendicular to the occlusal plane, and section lines were assigned to the A, B, and C planes according to the reference of Smith *et al.* (1991).

In each anterior aspect of the sectioned specimens, the area of spongy bone in relation to the total sectional area was measured and the ratio of spongy bone to cortical bone was calculated by an image analyzer with an analytical measuring system (London Road Pampisford, Cambridge, England) and VIDAS

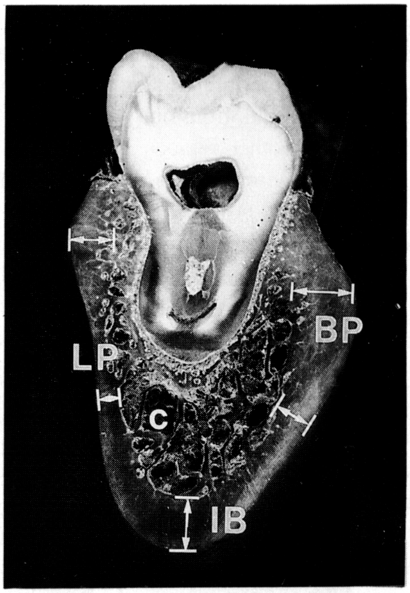

Fig. 3. Measurements of the mean cortical width of the mandible (BP: Buccal cortical plate, LP: Lingual plate, IB: Inferior border, C: Mandibular canal).

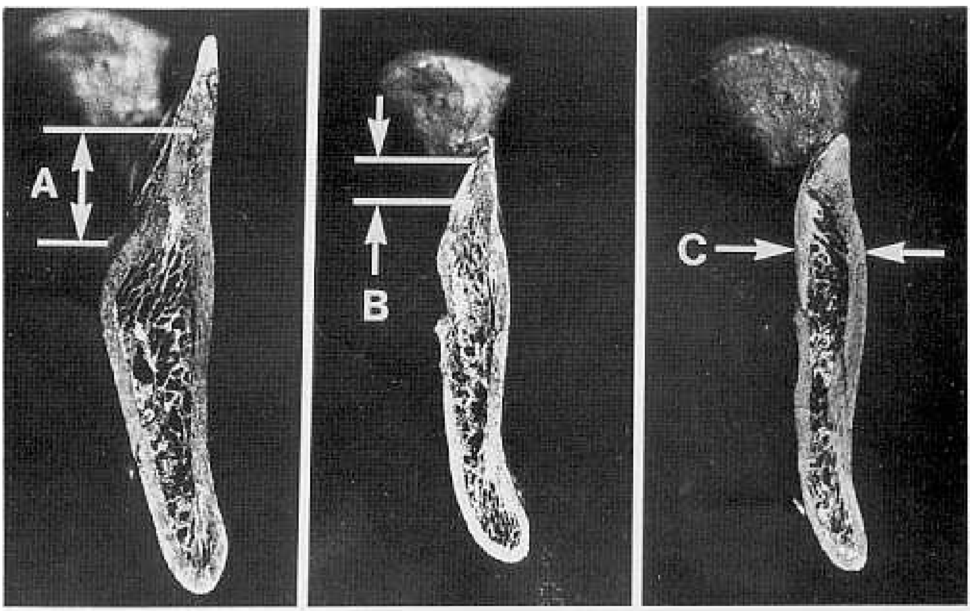

Fig. 4. Measurements in sections. A: vertical distance from the mandibular lingula to the fusion point of the buccal and lingual cortical plate at section A, B: vertical distance from the depth of the mandibular notch to the fusion point of the buccal and lingual cortical plate at section B, C: ramus thickness at the mid-point between the tip of the mandibular lingula and the depth of the mandibular notch at section C.

VI program on the photograph. On the same sections, mean cortical widths (MCW) of facial, lingual cortex and the inferior border of the mandible were taken. Results from one section were compared to those of other regions (Fig. 3).

The following measurements were made on each sectioned specimen: 1) The vertical distance from the mandibular lingular tip to the point at which the buccal and lingual cortical plates of the mandibular ramus become fused. 2) The vertical distance from mandibular notch to the point at which the buccal and lingual cortical plates of the mandibular ramus become fused. 3) The mean ramus thickness at the mid-point between the mandibular lingula and mandibular notch by using a dial gauge capable of measuring to the nearest 0.05 mm (Fig. 4).

All the measurements of the different subjects and regions were compared by a statistical package, PC-SAS v 6.04.

RESULTS

The position of mandibular lingula

The average horizontal distance from the anterior ramus border to the mandibular lingular tip was 17.4 mm in dentulous adult mandibles. The lingular tips were located somewhat posteriorly at the point which is 54% (length ratio) of the width of the mandibular ramus from the anterior ramus border in dentulous and edentulous adult mandibles. Whereas lingular tips of mandible in the mixed dentition were located more posteriorly at the point which is 56% (length ratio) of the width of the mandibular ramus (Table 1).

Referring to the superior-inferior relation of the mandible, lingular tips were located at the point which is 32% (length ratio) of the ramal length from the mandibular notch to the antegonial notch in adult dentulous mandibles, 30% (length ratio) in the adult edentulous mandibles and 37% (length ratio) in mandibles with mixed dentition. This means that the mandibular lingula moves forward and downward with aging (Table 2).

The horizontal distance from the distal side of the mandibular second molar to the lingular tip was 28.7 ±2.87 mm and the lingular tip was located above the occlusal plane and the average vertical distance was 5.9±2.62 mm in adult mandibles, and 0.4± 0.78 mm in children's.

The morphology of spongy and compact bone in the sectioned specimens

On the sectioned specimens, the ratio of cancellous bone to the total area was largest in the ascending ramus region and decreased gradually towards the anterior ramus region. In terms of bony composition, mean cortical width (MCW) of the facial cortical plate increased toward the ramus region, and that of the lingual cortical plate was thinnest in the ramus region. On the other hand, the width of the inferior border was almost the same in every region (Table 3).

The average vertical distance from the lingular tip to the point at which the buccal and lingual cortical plates become fused was 14.3 mm in section A, 7.9

Table 1. Measurements of the location of the mandibular lingula in the anterior-posterior relation of the ramus

	Dentulous mandible	Edentulous mandible	Mixed dentition
Anterior Border - Lingula(A)	17.5±2.6	17.3±2.4	6.0±2.0
Anterior Border - Posterior Border(B)	32.7±2.8	32.2±3.4	28.5±1.7
A/B	0.54	0.54	0.56

Mean±SD (mm), A/B = length ratio

Table 2. Measurements of the location of the mandibular lingula in the superior-inferior relation of the ramus

	Dentulous mandible	Edentulous mandible	Mixed dentition
Mandibular notch - Lingula(C)	15.1±2.3	14.5±3.5	14.2±2.1
Mandibular notch - Inferior Border(D)	47.9±4.8	47.4±4.9	38.9±4.4
C/D	0.32	0.30	0.37

Mean±SD (mm), C/D = length ratio

Table 3. Mean cortical width of Korean mandibles

Mandibular region	Mean cortical width		
	Facial cortex	Lingual cortex	Inferior border
1st molar region (mesial root)	2.5±0.5|	2.2±0.5|	3.5±0.8|
1st molar region (distal root)	2.8±0.6|	2.1±0.4|	3.3±0.7|
2nd molar region	3.0±0.7|	1.9±0.4|	3.2±0.6|
3rd molar region	2.9±0.7|	1.8±0.4|	3.2±0.7|
ascending ramus region	2.0±0.5|	1.7±0.4|	3.5±1.2|

Mean±SD (mm)
In each column, means with the same lines are not significantly different (p<.05)

mm in section B and 10.2 mm in section C. There was no case found in which the fusion point was located beneath the mandibular lingula (Fig. 4A).

The average vertical distance from the mandibular notch to the point at which the buccal and lingual cortical plates become fused was 1.3 mm in section A, 6.3 mm in section B and 4.0 mm in section C (Fig. 4B).

The average thickness at one-half the distance from the tip of the mandibular lingula to the depth of the mandibular notch was 6.3 mm in the anterior ramus, 5.7 mm in the middle ramus and 6.2 mm in the posterior ramus (Fig. 4C).

DISCUSSION

The mandibular lingula, a critical reference point in the performance of mandibular orthognathic surgery, or even in a simple dental anesthetic procedure, changes its position with age, thus implying great clinical importance (DuBrul, 1980). In this study, we found that the tip of the adult mandibular lingula was located at 1/3 portion of the mandibular ramus, somewhat postero-superiorly, and those of children were located more postero-inferiorly than in adults. This means that resorption of bone occurs at the mandibular notch and apposition at the inferior border, resulting in downward ramus growth. Similarly, resorption at the anterior border and apposition at the posterior border result in backward growth (Ranly, 1988).

Performing the SSRO, the position of the mandibular lingula is of vital importance because the osteotomy is performed at the region around the mandibular lingula during the medial horizontal osteotomy. We have measured it to be 28.7±2.87 mm in horizontal distance from the distal surface of the mandibular second molar to the tip of the mandibular lingula. Before medial horizontal osteotomy is performed, the position of the mandibular lingula related to the mandibular 2nd molar should be helpful as reference to clinicians, providing them with a foresight as to where they should expect to find it and to protect the inferior alveolar nerve and vessels along with it.

According to previous reports, the medial horizontal osteotomy should be "just above the mandibular lingula" (DalPont, 1961; Epker, 1977; Rajchel *et al.* 1986), thus enabling the clinician to prevent problems encountered during the bony splitting of the mandible. And this is in accordance with the anatomical fact that spongy bone increases in amount toward the inferior border, indicating that the width between the buccal and the lingual cortical plate is greater at the lower border and decreases as it goes upward. This anatomical structure contributes to increasing the chance of a bone fracture during the osteotomy (Epker, 1977). So far, there are many suggestions as to the modifications of treatment modalities. But since they are based upon sheer clinical observations and experience, actual anatomical studies should be performed to confirm such methods.

In this study, we found that all the fusion points of the cortical and lingual plates of Korean mandibles were located above the mandibular lingula. But unlike this study, Smith *et al.* (1991) reported that the fusion points of bony plates of Indian mandibles were above the mandibular lingula by 2.0%, 4.1% and 6.1% in the sections A, B and C respectively, differing from the results in Koreans. The B section of the Korean mandibular rami showed 2 cases fused at 4 mm beneath the mandibular lingula, but in almost all cases, it was located 10 mm above the lingula on average. This fusion point was actually closer in distance to the mandibular notch than the mandibular lingula. This result suggests that the medial horizontal osteotomy should be done just above the mandibular lingula in order to prevent any inadvertent bony fractures.

Anatomically, Mercier (1973) found that the mandibular ramus became progressively more cortical and less medullary as one proceeded posteriorly. So, the structure of cortical and cancellous bone must be considered in surgical planning or in determining the prognosis. The qualities and quantities of the jaw bone will influence the success rate of bone surgery because it is known that interosseous fusion following mandibular orthognathic surgery mainly occurs in the cancellous bone and that osseointegration between the metal and jaw bone mainly occurs in the trabeculae of the cancellous bone supporting the implant during the healing process (Brånemark, 1983).

Generally, it was known that the mandibular facial cortex was thinner at the mandibular anterior tooth region and thicker towards the mandibular molar region, while the mandibular lingual cortex was thin at the mandibular second and third molar region (DuBrul, 1980). According to this study, the mean width of the facial cortex increased toward the mandibular ramus region, being greatest at the second molar region and that of the lingual cortical plate was smallest in the ramus region. On the other hand, the width of the inferior border was almost the same in every region ($p<.05$) (Table 3). On the same sectioned specimens of the mandibular body and ascending ramus, the ratio of cancellous bone to the total sectional area was largest in the mandibular ascending ramus region, decreasing in the posterior region of the ramus. So this showed that the composition of the cancellous bone in the posterior mandibular ramus region was small.

Up to now, it was recommended that the medial horizontal osteotomy should be extended as far back as possible from the tips of the mandibular lingula and there was one report that the average length of the line would be 18 mm (DalPont, 1961; Hunsuck, 1968; Epker, 1977). But it is difficult to determine how much and how far back the medial horizontal osteotomy should be extended. In Koreans, we knew that the cutting line of the medial horizontal osteotomy should not be extended to the posterior border of the mandibular ramus, but should be extended at least 5-8 mm posterior to the lingula. At a more posterior portion of the mandibular ramus, a medial cut may facilitate a problematic split.

Taken together, we have presented the anatomical characteristics of Koreans associated with SSRO that may minimize some of the possible complications. In performing the SSRO on Koreans, the medial horizontal osteotomy should be done within 4 mm superior to the mandibular lingula to maintain adequate bone thickness. Also, the cut line of the medial horizontal osteotomy should be extended 5-8 mm posterior to the mandibular lingula and the lateral vertical osteotomy should be performed at the mandibular first and second molar to preserve sufficient cortical width to strengthen the involved osseous segments and reduce possible complications in surgical procedure.

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