Mandibular ramus thickness based on cone beam computed tomography scan

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Abstract. Mandibular ramus thickness is one of the most important factors that must be considered while performing bilateral sagittal split osteotomy (BSSO). Unfavourable fracture or bad split could occur while performing BSSO if the mandibular ramus is thin. To the best of our knowledge, there are only a few published reports with anthropometric data about the thickness of the mandibular ramus. The objective of this study was to measure the thickness of the mandibular ramus based on cone beam computed tomography (CBCT) to be used as a reference while performing BSSO. The study subjects comprised 61 data samples of CBCT-based DICOM images which reoriented in three planes, and we measured the thickness of the mandibular ramus. The mean thickness was 8.049 + 1.205 mm for males and 8.463 + 1.358 mm for females. For 18–30-, 31–40- and 41–50-year-old patients, the mean thickness of the mandibular ramus was 8.087 + 1.29 mm, 8.176 + 1.49 mm and 8.742 + 1.04 mm, respectively. Based on the CBCT images, there were no statistically significant differences between the thicknesses of the mandibular ramus in terms of sex and age.

1. Introduction
Malocclusion is an irregular biting or chewing relationship between the teeth on the jaw curve when the jaw closes. It can occur along with facial skeletal disharmony, wherein the relationship between the upper and lower jaw is inaccurate, commonly referred as skeletal malocclusion. Prognathism and retrognathism are common skeletal malocclusions caused by faster or slower jaw growth [1, 2].

Orthognathic surgery is a procedure for the correction of skeletal malocclusion [3]. It is divided into four categories, namely, mandibular, maxillary, bimaxillary and bimaxillary with genioplasty [4]. Technically, orthognathic surgical techniques are divided into two major groups: total body osteotomy and segmental osteotomy [4].

Bilateral sagittal split osteotomy (BSSO), one of the orthognathic surgical procedures, involves the total osteotomy of the mandible, and it is a common orthognathic surgical procedure to correct mandibular deformities. The indications for BSSO include the correction of malocclusion skeletal class II and III angles, dento maxillofacial deformity, mandibular laterognathia, mandibular asymmetry and mandibular deficiency [5, 6]. The BSSO procedure was popularised by Trauner and Obwegeser in 1955 and then modified by Dalpont, Hunsuck, Bell and Epker [4, 7, 8].
While performing osteotomy during BSSO, one complication that can occur is an unfavourable fracture called a bad split. Bad split can cause mechanical instability, bone healing disorders, infections and inferior alveolar nerve damage due to excessive intraoperative manipulation while attempting the repositioning of the fracture segments [7, 9, 10]. Mandibular anatomical structure is an important factor in the BSSO procedure. Mandibular ramus is one of the anatomical features that can cause difficulties during the BSSO procedures, although BSSO is a technique commonly used in the correction of mandibular deformity [11]. A thinner mandibular ramus is more likely to have complications [4, 10, 12]. The difficulties that occur with thinner mandibular ramus while performing osteotomy include the placement of horizontal osteotomy more buccal, which may cause complications [13].

Another anatomical feature that can be a reference to avoid injury to the inferior alveolar nerves during BSSO is the lingula. The lingula is found in the medial mandibular ramus in the superoanterior direction of the mandibular foramen. The mandibular foramen is the entrance of the inferior alveolar nerves into the mandible. Horizontal osteotomy is performed above the lingula to avoid injury to the inferior alveolar nerves [8].

Orthognathic surgery requires proper diagnosis and good planning of care, including clinical evaluation, facial analysis and radiographic examination [4]. Mandibular density or thickness is known to minimise the risk of bad split. The mandibular ramus thickness can be evaluated using three-dimensional (3D) radiographic methods such as computed tomography (CT) and cone beam CT (CBCT). Two-dimensional (2D) conventional radiographs such as panoramic and cephalographic images have limitations while determining mandibular ramus thickness due to the superimposition factor [14].

CBCT, a 3D diagnostic tool, is specifically developed for the maxillofacial region. It provides comprehensive diagnostic information and a craniofacial anatomical illustration for accurate diagnosis, treatment plan and prognosis. The CBCT images show a wide area of the facial bones or can focus on the desired area [15].

The most important advantage of CBCT is its ability to obtain 3D images, thereby overcoming the overlapping problem of anatomical structures that occur while using 2D imaging. CBCT is ideal for imaging the craniofacial area as it has high-image clarity and contrast quality which is best to view and evaluate the surrounding bone and bone tissues in detail. In addition, it has a high degree of accuracy that can be compared to the actual shape, size and structure of the teeth and bones [16, 17, 18, 19].

Mandibular thickness has not been widely studied. Anthropometric measurements are used to assess the variations and changes in the size and shape of the human body. The anthropometric data about mandibular ramus thickness is often used as a reference if BSSO is to be performed [20]. Until recently, there has been no research on the anthropometric data of the mandibular ramus, and in Indonesia, this research has never been conducted. In South Korea, mandibular ramus thickness was investigated by Jae Min Song and Yong Deok Kim in 2014, showing normal ramus thickness of 7 mm [14]. The research conducted by Ribiero et al. in Brazil in 2006 found that mandibular ramus thickness in patients with prognathism ranged from 6.1 to 12.5 mm and in patients with mandibular retrognathia, the thickness ranged from 6.9 to 10.6 mm [11].

Based on the background and data that have been presented, this study was designed to obtain that mandibular ramus thickness data in Indonesian individuals to be used as a reference for BSSO technique, particularly in diagnostic facilities with limited or unavailable 3D imaging.

2. Methods

This study was an analytical descriptive study with a cross-sectional design using secondary data from CBCT imaging of patients from R.E. Martadinata Ladokgi Dental Hospital and with ethical approval from the Dental Research Ethics Committee of the Faculty of Dentistry, Universitas Indonesia.

This study was conducted at the R.E. Martadinata Ladokgi Dental Hospital and Universitas Indonesia from October to December 2016. The inclusion criteria included male and female subjects aged between 18 and 50 years who underwent CBCT scan between 2010 and 2015 at the R.E. Martadinata Ladokgi Dental Hospital. The exclusion criteria for the study included pathological abnormalities affecting the mandible, maxillofacial growth disorders and edentulous jaw.
The sample size of the study was calculated using G*Power (version 3.0.10, Germany) with \( \alpha \)-value of 0.05 and \( \beta \)-error of 80%. Using the Lemeshow formula, it was found that the minimum sample size was 37.

The research procedures included the selection of CBCT result data of patients who met the inclusion criteria. The Digital Imaging and Communications in Medicine (DICOM) data was viewed using the Osirix LXIV software. It was reoriented to the sagittal field using the occlusal plane reference line, the axial plane using the posterior edges of the right and left mandibular rami and the coronal plane using the occlusal plane reference line on the right and left posterior teeth. The lingula position determination was done on the side to be measured using a coronal cut to specify the lingua peak level. This point is referred to as point A. The tangent line on the lingual side that is relatively parallel to the mandibular rumps of the spine is point B. Further, the thickness of the mandibular ramus from the outer lingual to the uppermost section is relatively perpendicular to the tangent point B.

The accuracy of the data obtained from two observers was expressed by technical error of measurement (TEM). Reliability was tested using the Dahlberg formula. After the test of reliability, statistical analysis was performed using SPSS for unpaired \( t \)-test and one-way ANOVA.

### 3. Results

The data review found 206 samples of CBCT-based DICOM images. There were 61 samples, including 34 females and 27 males. Based on the age group, there were 12 males and 19 females in the 18–30-year-old group, 6 males and 8 females in the 31–40-year-old group and 9 males and 7 females in the 41–50-year-old group.

The measurement of mandibular ramus thickness on CBCT images was performed by two observers in two observations at different times. The accuracy of the data obtained from the observers is expressed by TEM using the Dahlberg formula. The TEM value for intraobserver reliability was 0.075 mm and interobserver reliability was 0.11 mm.

Statistical analysis was performed using SPSS software. The average thickness of the mandibular ramus was 8.049 mm for males and 8.463 mm for females. The average thickness of mandible ramus was 8.087 mm in the 18–30-year-old group, 8.176 mm in the 31–40-year-old group, and 8.742 mm in the 41–50-year-old group.

Normality testing was done using the Kolmogorov–Smirnov test as the sample size was \( >50 \). The results showed that sex and age group variables had normal data distribution (\( p > 0.05 \)). The normally distributed data were analysed using unpaired \( t \)-test for sex variables and one-way ANOVA test for age group variables. The results are shown in Tables 1 and 2. Table 1 shows the results of the non-pairing of the mandibular ramus thickness in females and males (\( p > 0.05 \)). These results indicate no significant difference between the mandibular ramus thickness among females and males.

#### Table 1. Results of comparative hypothesis testing on sex variable

| Ramus Thickness | Sex   | n   | Mean ± SD | \( P \)-value |
|-----------------|-------|-----|-----------|--------------|
|                 | Female| 68  | 8.463 ± 1.358 | 0.078 |
|                 | Male  | 54  | 8.049 ± 1.205 |

*\( P > 0.05 \)

Table 2 shows the results of the one-way ANOVA testing which shows a significance value greater than 0.05 (\( p > 0.05 \)). These results indicate no significant difference in the mandibular ramus thickness among the age groups.

#### Table 2. Results of comparative hypothesis testing on age variables

| Age   | N   | Mean ± SD | \( P \)-value |
|-------|-----|-----------|--------------|
| 18–30 | 62  | 8.087 ± 1.29 | 0.061 |
| 31–40 | 28  | 8.176 ± 1.49 |
| 41–50 | 32  | 8.742 ± 1.04 |

*\( P > 0.05 \)
4. Discussion
Initially, 206 CBCT-based DICOM samples were found; however, most of these samples did not meet the inclusion criteria. Therefore, the remaining 61 qualifying samples comprised 34 females and 27 male patients.

The TEM values using the Dahlberg formula are acceptable for bone and teeth measurements wherein the measurement tolerance was 1 mm, so the data was considered reliable for further statistical calculations. When the TEM value differences were >1 mm, the results were not considered reliable. The analysis using the SPSS software was performed only if the data was reliable.

The measurements of the mandibular ramus thickness based on sex show some differences, although not statistically significant. Sex variability may be attributed to the women experiencing puberty at an average age of 10 years, whereas men usually undergo puberty at approximately the age of 14. During puberty, the size of the mandible rapidly increases. Mandibular growth in women ceases by the age of 14, whereas in men, the growth stops by the age of 16. Therefore, the mandibles of women and men have relatively similar periods of growth, so the sizes are relatively similar [21].

This result is different from that obtained by Jae Min Song and Yong Deok Kim (2014) in South Korea on patients with mandibular asymmetry prognosis showed that the study of the normal size of the normal mandibular ramus was significantly different in men 7.42 mm and 6.71 mm [14].

According to Sondang et al. the differences between the Korean and Mongolian populations are possibly due to the genetic differences in the environmental and population model. According to Munandar and Snow, Indonesian individuals have facial features that are brachicephalic with a square jaw. According to Hyun Jin Kim et al. Koreans have a longer face shape (dolichocephaly). This is possibly the reason that the individuals from Indonesia to have a wider jaw than those from Korea [22, 23]. The differences in the size of the mandibular ramus between the South Korean research and this study are possibly due to the different measurement techniques used. Jae Min Song and Yong Deok Kim (2014) used the Frankfurt horizontal plane as a reference field of the horizontal and midsagittal plane as a reference field of the sagittal direction [14].

Although statistically not significant, the measurements show that the mandibular thickness is slightly larger in women than that in men. This may be because after four years of age, there is a change in the mandibular shape and size, with jaws of women being larger than those of men. Before the age of four, the male and female jaws tend to be similar in terms of shape and size [21].

In the measurement of mandibular thickness divided by the age group, there is a tendency of an increase in the ramus thickness as age increases. In the 18–30-year-old group, the average thickness of ramus was 8.087 mm. In the 31–40-year-old group, it was 8.176 mm; in the 41–50-year-old group, it was 8.742 mm. However, these differences were not statistically significant.

Although the differences are not statistically significant, the measurements in the 40–50-year-old group are almost 7-mm larger than those in the 18–30-year-old group. This result is possibly because the mandible will reach its peak size at age 35, so the thickest mandibular ramus of the 40–50-year-old group will considerably be larger [21].

This study has the disadvantage of a small sample size, and it does not consider nutritional factors or the genetic background differences that may affect the mandibular ramus thickness. As a reference for BSSO, future follow-up study may consider the lingula position of the anterior ramus, posterior ramus and superior ramus and include the measurement of mandibular ramus minimal thickness values [8, 13].

5. Conclusion
In conclusion, there is no significant difference between mandibular ramus thickness in men and women or among age groups.

6. References
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