



MANDIBULAR RADIOGRAPHIC ANALYSIS FOR GENDER DETERMINATION OF DOWN SYNDROME SUFFERERS

ANALISIS RADIOGRAFI MANDIBULA UNTUK DETERMINASI JENIS KELAMIN PADA PENDERITA SINDROM DOWN

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ABSTRACT

Background: Natural disasters frequently occur in Indonesia, creating a need for effective victim identification. Gender identification is a crucial initial step, as it can narrow the search space by 50% during individual identification. The corpus and ramus mandible are an organ that plays an important role in gender prediction with a high predictive accuracy. However, the Down syndrome mandibular size is different from that of normal people. **Purpose:** To analyze the difference in corpus length and total height of the mandibular ramus between individuals with down syndrome and those without, as a step to gender determination. **Method:** This observational cross-sectional study involved 12 individuals with down syndrome and 12 individuals without, aged 10–17 years. The mandibular corpus length was measured through panoramic radiography from the gonion to the menton point. The mandibular ramus was measured from the apex of the condyle to the gonion point using the Clinicview application. Data were analyzed using the T-test with SPSS Ver. 26 software. **Result:** The length of the mandibular corpus differs significantly ($p\text{-value} = 0.000$) between Down syndrome with normal people. The length of the mandibular corpus in down syndrome does not differ significantly ($p\text{-value} > 0.000$) between males and females. The total height of the mandibular ramus does not differ significantly between down syndrome and non-down syndrome groups, both in males and females. **Conclusion:** The corpus length and the mandibular ramus's total height cannot be used as indicators of gender determination in down syndrome.

ABSTRAK

Latar belakang: Bencana alam yang sering terjadi di Indonesia memerlukan identifikasi korban. Identifikasi jenis kelamin adalah langkah pertama yang penting dilakukan karena dapat menentukan 50% probabilitas kecocokan dalam identifikasi individu. Korpus dan ramus mandibula memiliki akurasi yang tinggi dalam memperkirakan jenis kelamin. Ukuran mandibula pada penderita sindrom down berbeda dari orang normal. **Tujuan:** Menganalisis perbedaan panjang korpus dan tinggi total ramus mandibula antara penderita sindrom down dan orang normal, sebagai langkah untuk menentukan jenis kelamin. **Metode:** Penelitian observasional dengan pendekatan *cross-sectional*. Kelompok penelitian terdiri dua belas orang penderita sindrom down dan dua belas orang normal berusia 10 - 17 tahun. Setiap subjek penelitian dilakukan pengambilan radiografi panoramik untuk memperoleh gambaran mandibula. Panjang korpus mandibula diukur dari titik gonion menuju titik menton mandibula. Tinggi total ramus mandibula diukur pada regio kanan dan kiri, yaitu dari titik puncak kondilus menuju titik gonion menggunakan aplikasi Clinicview. Data dianalisis menggunakan uji T dengan software SPSS Ver. 26. **Hasil:** Panjang korpus mandibula berbeda signifikan ($p\text{-value} = 0,000$) antara penderita sindrom down dengan orang normal. Panjang korpus mandibula pada sindrom down tidak berbeda signifikan ($p\text{-value} > 0,000$) antara laki-laki dengan perempuan. Tinggi total ramus mandibula tidak berbeda signifikan antara sindrom down dengan orang normal, baik pada laki-laki maupun perempuan. **Kesimpulan:** Panjang korpus dan tinggi total ramus mandibula tidak dapat digunakan sebagai indikator menentukan jenis kelamin pada penderita sindrom down.

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INTRODUCTION

Indonesia is one of the countries most prone to natural disasters, both in terms of geology, climatology, and socio-demographic aspects. Geologically, Indonesia lies within the Pacific Ring of Fire, a region known for intense tectonic activity. These geological factors make Indonesia vulnerable to volcanic eruptions, earthquakes, and tsunamis (Nazaruddin, 2015). Not all disaster victims can be successfully identified, which underscores the critical importance of forensic medicine and related disciplines in such situations. Proper identification is particularly essential when significant physical damage has occurred, requiring the expertise of forensic specialists to manage and analyze human remains. Managing significant numbers of deceased individuals after a disaster or in a post-conflict setting, in terms of human identification, is a fundamentally different routine than a regular job (Cordner, 2018). The big earthquake has an impact on the risk of injury to the victim (Muhammad *et al.*, 2024; Prawestiningtyas and Algozi, 2009). Personal identification can be performed using two main approaches: (1) Primary identification, which involves fingerprint analysis, DNA profiling, and dental examination, and (2) Secondary identification, which includes gender determination (Interpol, 2023). Secondary identification can also be carried out to narrow down the alleged victim through photographic, visual, medical, cheiloscopy and palatoscopy examinations, and the victim's property (Nagalaxmi *et al.*, 2014).

Sex identification within the scope of anthropology and forensic dentistry can be carried out by various methods, including morphometric methods (measurements), histological examinations, and DNA analysis examinations (Elfitri *et al.*, 2017). Forensic identification is an effort carried out to help investigators predict a person's identity. Forensic odontology has a role in the identification of victims, especially in unknown bodies, bodies that have decayed, damaged, burned in mass accidents, and especially in natural disasters that often occur in Indonesia (Ekkarandy and Arafat, 2021). Gender identification for disaster victims is very important because it is part of respecting and realizing the human rights of the deceased. Each corner of the anatomical part of the jawbone has characteristics that differentiate between women and men, both in terms of size and shape (Sukmana *et al.*, 2022).

The occurrence of disasters in Indonesia must be carefully considered, as not everyone can save themselves easily, particularly vulnerable groups such as the elderly, pregnant women, children, and people with intellectual disabilities (down syndrome). The incidence of down syndrome is estimated to be 1 in 800 - 1000 births. The frequency of down syndrome in Indonesia is 1 in 600 live births. The overall prevalence is 10 down syndrome per 10,000 live births worldwide (Irwanto *et al.*, 2019). WHO estimates that there are 8 million people

with down syndrome worldwide. Down syndrome cases in Indonesia tend to increase. Cases of down syndrome in children 24 - 59 months based on the results of Basic Health Research in 2010 were 0.12%, in 2013 it was 0.13% and increased to 0.21%. Down syndrome contributed the second largest birth defect at 0.21% after at least one type of disability at 0.41% (Ministry of Health, 2018).

Down syndrome sufferers can be easily recognized because they have the most distinctive characteristics, namely seen from the brachial shape of the head, epicanthic folds, oblique palpebral fissures, and lower mandibular plane angles. People with down syndrome have a much slower mandibular growth rate than those without the condition (Salmiah and Mustafa, 2016). Gender identification can be done through the maxillary and mandibular arches. Each corner of the anatomical part of the jawbone has characteristics that differentiate between female and male, both in terms of size and shape which can be assessed to differentiate between male and female remains during forensic identification (Sukmana *et al.*, 2022). The difference in the height of the mandibular ramus between males and females is due to the difference in chewing style between males and females (Kaur *et al.*, 2021; Sharma and Sharma, 2022).

Mandibular growth is a constant process of remodeling. Bone reposition and bone resorption that occur with age cause the shape and size of the mandible to change (Azhari *et al.*, 2019). The growth of mandibular bone is influenced by several factors, such as genetic, hormonal, nutritional, socioeconomic, climatic and which can either delay or accelerate bone growth. Down syndrome is one of the most frequent causes of delayed bone development. Individuals with this condition often exhibit a prognathic mandible due to insufficient maxillary growth, which does not correspond to mandibular development (Carinhena *et al.*, 2014). Changes in the shape and size of the mandibles can be analyzed by radiography. Radiography can help in showing accurate measurements for specific formulas that can be used for gender prediction (Nadendla *et al.*, 2016). Several studies prove that panoramic radiography can be used to evaluate morphometrics in the mandible (Rani *et al.*, 2019). Panoramic radiography can be used to measure the vertical and horizontal dimensions of the mandible, such as calculating the height of the mandibular ramus, the length of the mandibular corpus, the gonial angle, the width of the bigonial, and the height of the condyle (Capitaneanu *et al.*, 2017). Sex estimation using skeletal identification is a key component of an individual's biological profile to achieve forensic, medico-legal, bio-archaeology, and anthropological goals (Rowbotham, 2016). Therefore, the purpose of this study is to analyze the difference in mandibular corpus length and total height of the mandibular ramus between people with down syndrome and those without, aged 10 - 17 years old, as a basis to determine gender.

MATERIAL AND METHOD

This study employed a cross-sectional research design carried out at Dental Hospital, University of Jember. This study used a total twenty-four subjects divided into two groups, namely down syndrome subjects who attended SLB Jember Regency aged 10 - 17 years old, and subjects without down syndrome of the same age. Each group is further divided into two subgroups, namely men and women. All 12 students with down syndrome attending the SLB were included in the study, and the number of control subjects (12 individuals without down syndrome) was matched to the number of down syndrome participants. This research was carried out for four months and all research subjects have agreed to the informed consent given.

All research subjects underwent panoramic radiography (Instrumentarium OP300D Panoramic, KaVo Kerr) to obtain an image of the mandible. Next, a panoramic photo analysis was carried out to measure the

length of the mandibular corpus by measuring from the gonion (Go) point to the menton (Me) point (Figure 1a) using the Clinicview ver 10.2.6 application, and with the same application, the total height of the mandibular ramus is also analyzed, by measuring from the highest point of the condyle (Co) to the lowest point of the ramus that intersects with the lower tangent of the mandible (Figure 1b).

Measurements of mandibular corpus length and mandibular ramus height were performed in two regions, both the right and left regions. The results of measuring the length of the mandibular corpus and the height of the mandibular ramus were carried out by finding the average length of the corpus and the total height of the mandibular ramus. All collected data were tabulated and normality tests were carried out using the Shapiro-wilk test, and homogeneity tests using Levene's test. Furthermore, an Independent T-test was carried out with a significance level of $p\text{-value} < 0.05$. This data analysis was carried out using SPSS for Windows software.

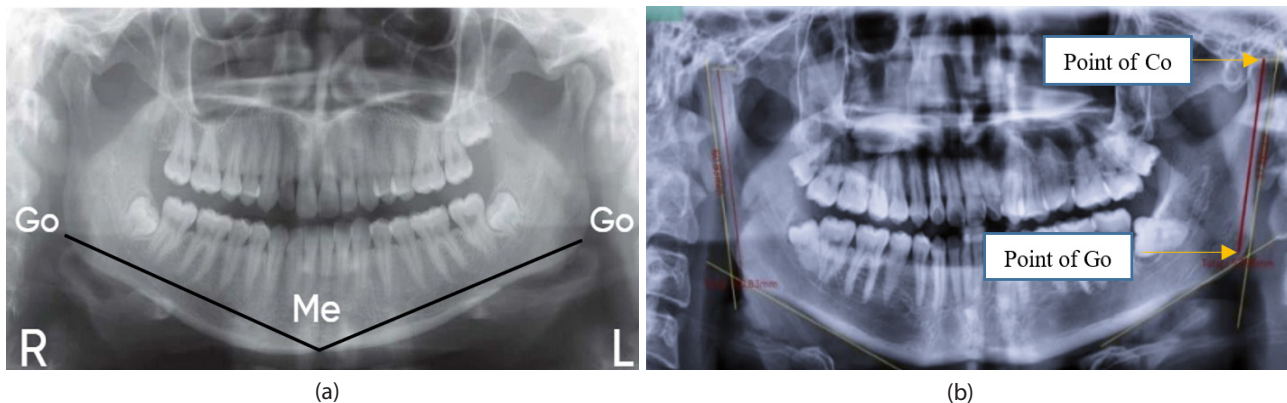


Figure 1. (a) Mandibular corpus length reference line (Astuti *et al.*, 2022) and (b) Measurement of mandibular ramus height (Salsabilla *et al.*, 2022). (Go = gonion point, Me = menton point, Co = condyle point, L = left, R = right)

RESULT

Based on the results of this study, the average value of the mandibular corpus length is presented in Table 1, and the total height of the mandibular ramus is presented Table 2. The length of the mandibular corpus in females with down syndrome is smaller than that in males with down syndrome, a trend also observed among individuals without the condition. This suggests that mandibular corpus growth in down syndrome is slower compared to those without down syndrome.

The average total height of the mandibular ramus in individuals with down syndrome was consistently lower than that of individuals without the condition. Among participants with down syndrome, males exhibited a greater total ramus height compared to females. As shown in Table 2, the total ramus height in the control group was lower in males than in females.

The results of the Shapiro-wilk normality test (Table 3) demonstrate that the data are normally distributed, thus enabling the T-test to be continued to examine the differences between two distinct groups. The results of the T-test for the mandibular corpus length are presented in Table 4, while the total height of the mandibular ramus is presented in Table 5.

Based on the results presented in Table 4, there was a significant difference in mandibular corpus length between males and females without down syndrome. The length of the mandibular corpus in individuals without down syndrome is also significantly different from that of people with down syndrome. However, there is an insignificant difference between male down syndrome sufferers and female down syndrome. There was no significant difference in the length of the left and right mandibular corpus in both down syndrome patients and males and females without the condition.

Table 5 demonstrates that there is no statistically significant difference in the height of the total mandibular ramus between individuals with down syndrome and the general population, irrespective of gender. Furthermore, the height of the total mandibular

ramus in males with down syndrome is not significantly different from that of females. No significant difference was observed in the total height of the right and left regions of the mandibular ramus between the normal population and those with down syndrome.

Table 1. Length of the mandibular corpus

Groups	Number of samples	Length of mandibular corpus + SD (mm)		
		Left region	Right region	Mean
Down syndrome male	5	68.28 ± 2.13	67.46 ± 2.59	67.87 ± 2.22
Down syndrome female	7	66.45 ± 2.67	65.76 ± 3.91	65.65 ± 3.06
Normal male	5	87.46 ± 1.11	87.44 ± 1.63	87.45 ± 1.20
Normal female	7	79.93 ± 3.05	80.72 ± 2.30	80.32 ± 2.53

SD: Standard of Deviation

Table 2. Total height of mandibular ramus

Groups	Number of samples	Total height of mandibular ramus + SD (mm)		
		Left region	Right region	Mean
Down syndrome male	5	45.78 ± 7.68	45.24 ± 6.29	45.51 ± 0.38
Down syndrome female	7	45.96 ± 3.92	44.74 ± 3.32	45.35 ± 0.86
Normal male	5	49.26 ± 8.39	48.54 ± 6.87	48.90 ± 0.50
Normal female	7	49.77 ± 4.97	48.38 ± 4.16	49.10 ± 0.98

SD: Standard of Deviation

Table 3. Length of mandibular corpus and total height of mandibular ramus normality test result

Groups	p-value of Saphiro-wilk	
	Mandibular ramus	Mandibular corpus
Down syndrome male	0.403*	0.210*
Down syndrome female	0.064*	0.878*
Normal male	0.627*	0.981*
Normal female	0.558*	0.543*
Down syndrome male (right region)	0.406*	0.645*
Down syndrome male (left region)	0.496*	0.530*
Down syndrome female (right region)	0.147*	0.067*
Down syndrome female (left region)	0.482*	0.604*
Normal male (right region)	0.714*	0.526*
Normal male (left region)	0.557*	0.258*
Normal female (right region)	0.905*	0.814*
Normal female (left region)	0.806*	0.381*

Table 4. T-test result of mandibular corpus length

Between two group	p-value T-test	Annotation
DS male - DS female	0.200	Not significantly different
DS male - Normal male	0.000	Significantly different
DS female - Normal female	0.000	Significantly different
DS male (right region) - DS male (left region)	0.604	Not significantly different
DS female (right region) - DS female (left region)	0.390	Not significantly different
DS male (right region) - DS female (right region)	0.225	Not significantly different
DS male (left region) - DS female (left region)	0.237	Not significantly different
DS male (right region) - Normal male (right region)	0.000	Significantly different
DS male (left region) - Normal male (left region)	0.000	Significantly different
DS female (right region) - Normal female (right region)	0.000	Significantly different
DS female (left region) - Normal female (left region)	0.000	Significantly different
Normal male - Normal female	0.000	Significantly different
Normal male (right region) - Normal female (right region)	0.000	Significantly different
Normal male (left region) - Normal female (left region)	0.000	Significantly different
Normal male (right region) - Normal male (left region)	0.976	Not significantly different
Normal female (right region) - Normal female (left region)	0.595	Not significantly different

DS: Down Syndrome

Table 5. T-test result of the mandibular ramus height

Between two group	p-value T-test	Annotation
DS male - DS female	0.988	Not significantly different
DS male - Normal male	0.479	Not significantly different
DS female - Normal female	0.104	Not significantly different
DS male (right region) - DS male (left region)	0.906	Not significantly different
DS female (right region) - DS female (left region)	0.473	Not significantly different
DS male (right region) - DS female (right region)	0.899	Not significantly different
DS male (left region) - DS female (left region)	0.917	Not significantly different
DS male (right region) - Normal male (right region)	0.513	Not significantly different
DS male (left region) - Normal male (left region)	0.451	Not significantly different
DS female (right region) - Normal female (right region)	0.143	Not significantly different
DS female (left region) - Normal female (left region)	0.097	Not significantly different
Normal male - Normal female	0.946	Not significantly different
Normal male (right region) - Normal female (right region)	0.897	Not significantly different
Normal male (left region) - Normal female (left region)	0.962	Not significantly different
Normal male (right region) - Normal male (left region)	0.886	Not significantly different
Normal female (right region) - Normal female (left region)	0.582	Not significantly different

DS: Down Syndrome

DISCUSSION

This study demonstrated a significant difference in mandibular corpus length between individuals with down syndrome and those without, with the former group exhibiting a shorter corpus length. This is also in accordance with the statement (Vicente *et al.*, 2020) that the cranial base in down syndrome subjects has experienced a reduction in length so that it is flatter than in normal subjects. In addition, the maxilla size in the sagittal direction also decreased, so that Class III malocclusion tended to occur. People with down syndrome often experience differences in mandible growth relative to the general population. People with down syndrome show a decrease in bone formation in the mandibles, which can lead to different forms of mandibles. In addition to differences in bone formation and jaw shape, people with down syndrome can also experience differences in the time and growth of mandibles, which are delayed by about two years compared to the general population (Macho *et al.*, 2014). People with down syndrome usually experience a delay in tooth eruptions by two to three years than normal people (Lamfon *et al.*, 2015). The small size of the mandible in down syndrome is due to the displacement and spread of damage to the mandibular nerve stem cells during embryonic formation, so the mandible cannot form properly (Primasari, 2016). The growth of mandibles in people with down syndrome is affected by various factors. These factors are genetics and environmental factors such as nutrition and overall health (Sabatini *et al.*, 2022).

The results of this study showed that the length of the corpus of normal males was longer than that of females, and there was a significant difference. This finding aligns with the statement (Astuti *et al.*, 2021) that the average length of the mandibular corpus in normal men is longer than that of normal women. The difference in mandibular corpus length in men and women can be caused by several factors, one of which is the hormone testosterone, which causes the length of the corpus in males to be longer than in females (Ubelaker and DeGaglia, 2017).

Mandibular length increases through a process of bone deposition on the posterior surface, balanced by bone resorption on the anterior surface. This remodeling causes the mandible to grow in a posterior direction over time. This causes the growth of the mandible to extend backward (Primasari, 2018). The growth of the mandibular corpus in the general population is influenced by several factors, including genetic factors, namely the growth of an individual's mandible similar to that of their parents. In addition, hormonal factors such as growth hormones, sex hormones, and thyroid hormones influence the growth of the mandibular corpus. The pituitary gland in the brain stimulates the production of other hormones that affect overall bone growth. Proper intake of nutrients, especially calcium,

phosphorus, vitamin D, and protein is necessary for optimal bone growth and development (Nielsen, 2022). The growth of the mandibular corpus is generally synchronous on both sides of the left and right, resulting in symmetrical facial development, but in an individual, there will be a difference in the length of the right and left mandibular corpus due to trauma that can interfere with the growth and development of the mandible (Rakhman *et al.*, 2022).

The results of this study showed that the total height of the mandibular ramus of people with down syndrome was lower than that of individuals without the condition, but there was no significant difference between the two. People with down syndrome experience delays in body growth and development, including oral growth and development. The growth and development delay that occurs in people with down syndrome is closely related to the presence of chromosomal abnormalities that cause intellectual disability, metabolic system abnormalities and slower growth compared to normal subjects (Dierssen *et al.*, 2020). The growth of mandibular bone in general goes through the process of deposition and resorption. New bone tissue is deposited in areas near the active growth regions, while other surfaces undergo resorption. Facial bones will undergo resizing and reshaping with the process of bone deposition and resorption which will later result in changes in shape, dimension, proportion, and regional adjustment that adapts to the development of bone function. In the mandibular ramus, there is a movement in the posterior direction which is a combination of deposition and resorption. During this process, remodeling of the anterior mandible facilitates overall bone enlargement and ensures that none morphology aligns with functional requirements. (Ardani, 2023).

The results of this study also showed that the height of the right mandibular ramus was higher than that of the left region, both in people with down syndrome and male and female subjects without the condition. This is in accordance with the research of (Joo *et al.*, 2013) which shows that the insignificant difference in the height of the mandibular ramus between the right and left regions can be caused by one of them due to a balanced chewing pattern and even pressure on both sides of the jaw. This is because the interaction between chewing muscles and mandibular and craniofacial bones is an important component in controlling craniofacial growth and temporomandibular structure.

The growth of jaw size in men is greater than in women. Hormonal factors plays a significant role in mandibular development, particularly during puberty, when estrogen levels increase in females and testosterone levels in males. These hormones can affect the bone remodeling process, stimulate hormone growth, and increase the number of bone matrix. Providing nutritional and nutrient intake, especially calcium, is necessary for optimal bone growth

and development (Nawawi *et al.*, 2018). Apart from nutritional factors, environmental factors that also affect are physical. Mastication habits such as consuming fine-textured foods will cause minimal use of the mastication muscles which results in changes in facial development so that the jaw will become narrower. Meanwhile, in individuals who have the habit of consuming coarse-textured food, it will increase the strength of the mastication muscles which can trigger the growth of sutura and bone aposition so that there is an increase in jaw growth (Primasari, 2018).

The results of this study show that there is a significant difference in the length of the mandibular corpus between people with down syndrome and those without the condition. However, the length of the mandibular corpus and the total height of the mandibular ramus in males and females with down syndrome did not differ significantly. Therefore, in the context of forensic odontology, these measurements cannot be reliably used for gender determination in individuals with down syndrome.

CONCLUSION

There is a significant difference in the length of the mandibular corpus between people with down syndrome and those without the condition. However, the length of the mandibular corpus in males with down syndrome did not differ significantly from that of females with down syndrome. There was no significant difference in total mandibular ramus height between down syndrome people and those without the condition. There was also an insignificant difference in the total height of the mandibular ramus between males and females with down syndrome. Thus, the length of the mandibular corpus and the total height of the mandibular ramus cannot be used as a reference in gender determination in people with down syndrome.

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AUTHOR CONTRIBUTION

R. C. P and D. K. A: conceptualization, data curation, acquisition of funding, investigation, methodology, supervision, validation. A. D. P. S. and H. M.: conceptualization, data curation, methodology, project administration, software, supervision, validation, visualization, writing - original draft, writing - review and

editing. N. F. and N. H.: formal analysis, acquisition of funding, resources, software, validation. A. F. and I. K. W.: conceptualization, supervision, validation, visualization. All authors discussed the results and contributed to the final manuscript.

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DATA AVAILABILITY

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request. The datasets generated and/or analysed during the current study are not publicly available due to the confidentiality of the data, but are available from the corresponding author on reasonable request.

CONFLICT OF INTEREST

The authors state there is no conflict of interest with the parties involved in this study.

ETHICAL APPROVAL

This research has been approved by the ethics committee with number 2724/UN25.8/KEPK/DL/2024 issued on July 25th 2024 by the Ethical Committee of Medical Research of Faculty of Dentistry of University of Jember.

INFORMED CONSENT

Research subjects provide consent by signing an informed consent form.

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