Original Article

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Mandibular condyle and ramus angles in healthy individuals: a multidedector computed tomography study

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Abstract

Objectives: The aim of this study was to determine the distribution of the mandibular condyle horizontal inclination angle and condyle-ramus angle among different age and gender groups in asymptomatic healthy individuals.

Methods: This study was conducted including computerized tomography (CT) images of 100 patients aged between 18–90 years.

Results: The mean horizontal angle was 22.37° on the right side, 23.32° on the left; the condyle-ramus angle was 97.40° on the right side, 98.39° on the left.

Conclusion: Knowing mandibular condyle horizontal inclination angle and condyle-ramus angle would be useful for radiologist during CT evaluation of mandible after a surgery or trauma and for surgeons to plan their approaches properly during surgical interventions.

Keywords: mandibular angles; mandibular condyle; mandibular ramus; temporomandibular joint

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Introduction

The mandible is the largest bone of the face. It is formed by a ramus and a body.[1] Ramus is the part that includes the condylar process. The condylar process has a neck and a head, also called the condyle, which makes the temporomandibular joint. The condyle lies in the glenoid fossa of the temporal bone. The mediolateral length of the glenoid fossa is more than its anteroposterior length, which makes it fit to the condyle. The condyle is approximately 15–20 mm in width, and 8–10 mm in anteroposterior length.[2]

After birth, the condyle grows in a superior-lateral-posterior direction while the height of the ramus increases and the mandibular fossa deepens.[3] Most of the growth of the body and the ramus happens at 5–6 years of age.[4] The mandibular shape and size finalize 2 to 3 years after menstruation in females, and 4 years after sexual maturity in males.[4] Therefore, the normalized angle and size measurements should be done after approximately 18 years of age.

Developmental malformations of the temporomandibular joint can be attributed to 7 to 11 weeks of gestation, which is the time that the neural crest cells migrate and form the first draft of the bone and cartilage.[5] Any disruption at this point in life may result in distinct morphological differences such as hypoplastic/aplastic, hyperplastic or bifid condyle.[6] Other than the developmental malformations, some acquired morphological disturbances may be seen with the condyle and the ramus secondary to trauma, or some systemic diseases such as rheumatoid or juvenile idiopathic arthritis.[7] This type of injury may result in function loss, malocclusion, ankylosis of joint, and deviation of the mandible.[8]

Since the morphology of the condyle is subject to changes due to various disturbances, it is important to know its normal position and its angles, as well the position and the angles related with the mandibular ramus. In this study, we aimed to evaluate the normal horizontal inclination angle of the condyle, the angle between the longitudinal planes of the condyle and ramus using multidetector computerized tomography (CT) for to evaluate any pathologies or malformations related with the temporomandibular joint. We also aimed to compare our results between genders and different age groups.

Materials and Methods

This study was conducted on CT images of 100 patients (49 females, 51 males) between 18–90 years of age. Patients younger than 18 years were not included because the bony growth finalize at around that age for both sexes.[4] The images were collected between 1st of January and 1st of May, 2022. The patients were undergone CT evaluation for any other reason than complaint or pathology related to temporal or mandibular area.

A multidetector CT (GE Healthcare, USA) was used to obtain the images. The parameters were used as; 120 kV, effective mAs= 150 mAs, slice thickness= 1 mm, matrix= 512×512, collimation= 128×0.6 slice increment=0.7 pitch= 0.8 field of view. Images were analyzed after obtaining from hospital's PACS system. All images were analyzed on the same 24-inch medical monitor with an ideal screen display.

Inclusion and exclusion criteria were decided upon the patients' CT images and health records on our hospital system. One of our main inclusion criteria was that both condyles could be seen symmetrical and simultaneously on the axial slices. If this was not the case, the image was replaced with another since the angles could not be measured correctly. Any patients with structural abnormalities seen during the evaluation were excluded as well. According to information gathered from patients' health records, any patient who had trauma, surgery or any kind of lesion related to our area of interest were not included in our research. Other inclusion criteria were the age of the patients and optimal quality of the CT scan without any artifacts (**Figure 1**).

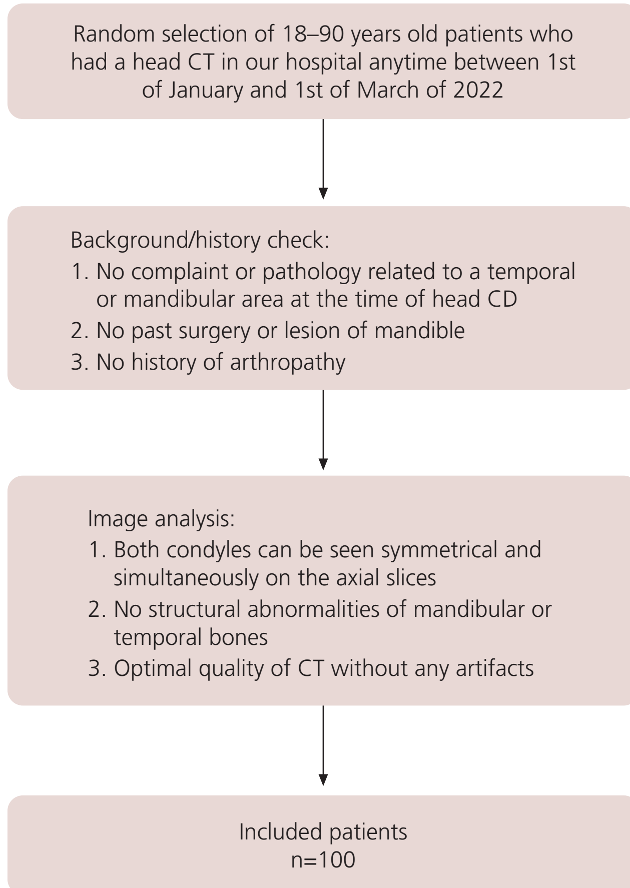

Figure 1. Flow-chart used in inclusion and exclusion criteria of patient selection.

The condylar horizontal inclination angle was measured as the angle between the longitudinal planes of the condyle and ramus on the ipsilateral side on the axial CT images. First, the midsagittal plane which separated the head into two symmetrical halves was determined. Then a perpendicular line to midsagittal plane was drawn, and defined as the coronal plane. After this, the maximum mediolateral length of the condyle seen on the appropriate axial images was determined. This can also be defined as the longest line connecting two sides of the condylar poles.[9] The angle between this line and the coronal plane was determined as the horizontal inclination angle (**Figure 2**). And the angle between this line and the longitudinal plane of the ramus was defined as the ramus angle (**Figure 3**). The axial slice that enables visualization of most of the ramus of mandible was determined and the longitudinal plane of the ramus was drawn through the midline of the ramus.

Two radiologists (5 and 15 years of experience) made the measurements twice at different times. The mean, standard deviation and range were calculated for descriptive statistics. Variables with normal distribution were expressed as mean±standard deviation. For comparison of angles on each side between gender and age groups, independent sample t-test was conducted for normally distributed parameters, and the Mann-Whitney U test was used for non-normally distributed. The intraclass correlation coefficient was used to evaluate the interobserver reliability for measurements. A significant difference was concluded if $p<0.05$. Statistical analyzes were

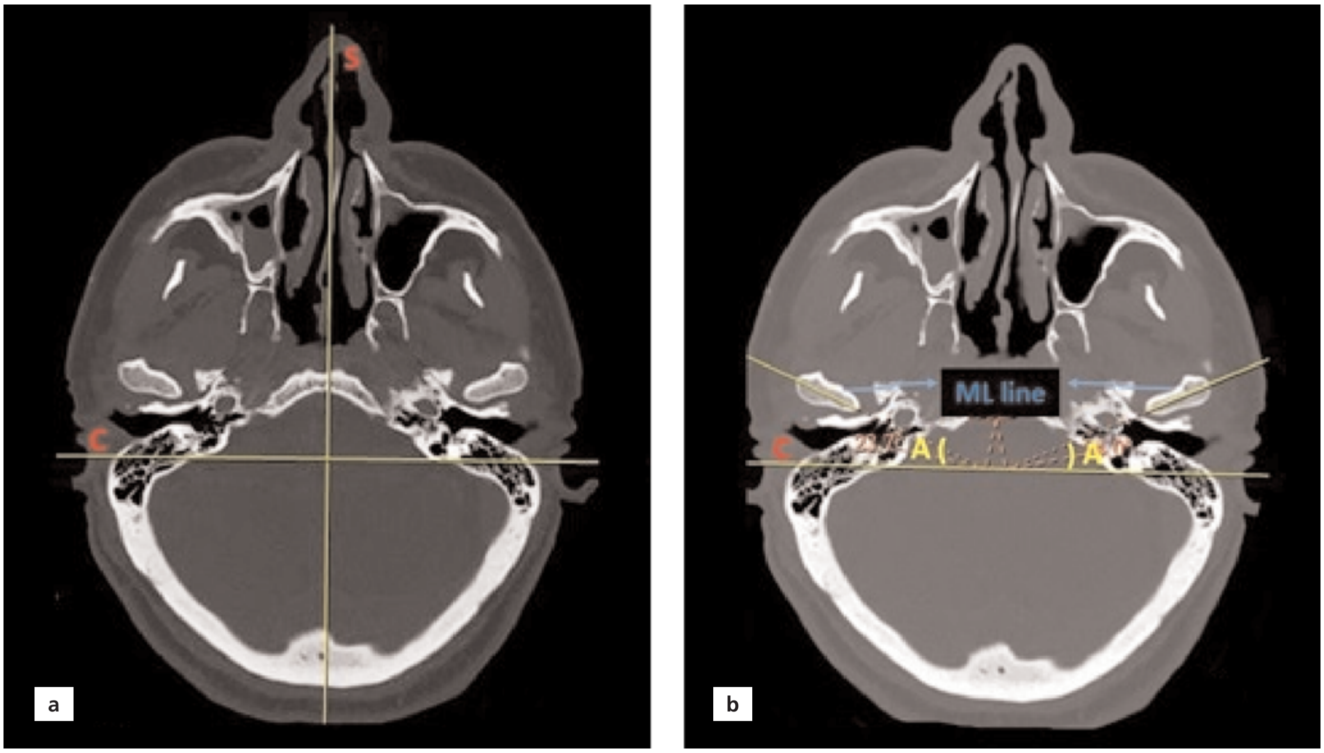

Figure 2. Axial CT images of the condylar horizontal inclination angle. (**a**) midsagittal (**S**) plane and coronal plane (**C**) are drawn perpendicular to each other; (**b**) mediolateral line (**ML line**) is determined for each condyle as the maximum length of the condylar poles. The horizontal angle of inclination (**A**) is measured on the coronal plane.

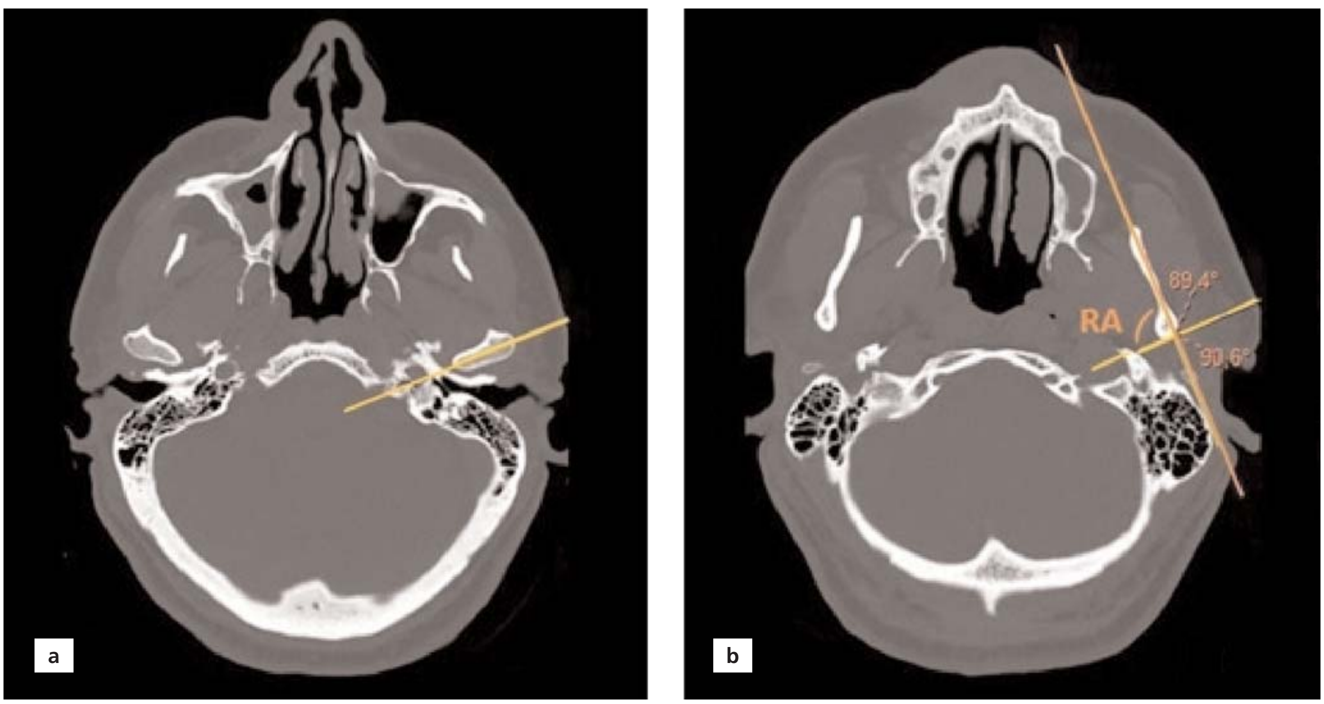

Figure 3. Axial CT images of the ramus angle. Mediolateral line of the condyle (**yellow line**) is drawn and (**a**) its projection is followed onto the consequent image until most of the ramus is visualized; (**b**) ramus angle (**RA**) is measured as the angle between the condylar line and the longitudinal plane of ramus (**orange line**) that goes through its midline.

Table 1
Mean and min-max values of the measurements.

	Mean (°)	Min–max (°)	Intraclass correlation coefficient	%95 confidence interval
Right horizontal inclination angle (n=100)	22.37	11.0–36.5	0.980	0.97–0.99
Left horizontal inclination angle (n=100)	23.32	5.5–38.0	0.968	0.95–0.96
Right ramus angle (n=100)	97.40	85.5–114.5	0.919	0.88–0.95
Left ramus angle (n=100)	98.39	81.75–116.5	0.901	0.85–0.93

performed with Statistical Package for Social Sciences (SPSS Version 23, Armonk, NY, USA).

Results

The mean age of patients in our research study was 48.5 years (range: 18–89 years) and the mean age was 48 for females (n=49) and 49 for males (n=51) (**Figure 4**).

Results of the measurements on each side were given in **Table 1**. The intraclass correlation coefficients were measured according to both researchers' results. The coefficient was found to be more than 0.9 for all measurements, which indicates excellent reliability. Therefore, statistical measurements were made by taking the average of both researchers' results.

The mean horizontal inclination angle was 22.37°± 5.85° for right condyle and 23.32°±6.17° for left. The ramus-condylar angle was 97.40°±5.58° on the right side and 98.39°±6.69° on the left. The angle between the condyles ("Co-Co angle") was measured by subtracting the sum of inclination angles of each side from 180°. So, the mean Co-Co angle was approximately 104.31°.

The statistical analyses showed no significant difference between right and left sides for both horizontal inclination and ramus condylar angles ($p>0.05$). The difference between females and males was also not statistically significant for both angles ($p>0.05$) (**Table 2**).

When the patients are divided into three age groups according to equated arrangement in a descending order, three groups were formed as in **Table 3**. There was no significant difference between age groups for both horizontal inclination and ramus condylar angles ($p>0.05$).

Discussion

In this study, we measured the mandibular condyle angles and ramus angles on axial CT images of 100 patients without a history of temporomandibular disease. The purpose of this study was to determine a mean value for these angles for clinical purposes, and to conclude whether there was any difference between gender and age groups or not.

Numerous factors can cause condylar angle discrepancies,[9,10] so it is important to distinguish the normal and abnormal condylar anatomy in order to recognize its diseases and disorders. In our study, we excluded any patients with disease that could alter the normal anatomy; such as systemic diseases,[11] bone diseases,[12] trauma[13] and any metabolic diseases.[14]

In a study done by Pamukcu et al.,[9] temporomandibular joints of 3 groups of people were investigated on healthy controls and patients unilateral and bilateral temporomandibular joint disease. The horizontal inclination angle of condyle was revealed as 19.5°±6.4° for the control group, which is less than our overall average (22.2°±5.5°). The mean inclination angle found in unilateral osteoarthritis group was 20.5°±6.5° and in

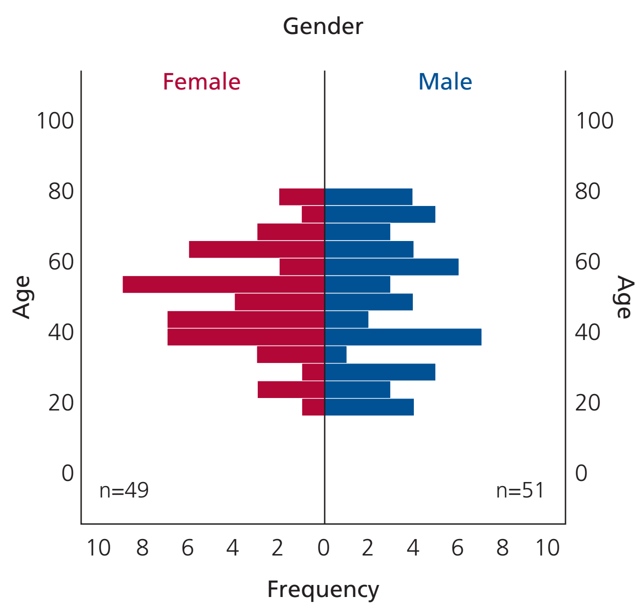

Figure 4. Distribution of patients according to their age and gender.

bilateral osteoarthritis group was 22.7°±7.6°. The results of the control group and the group of unilateral osteoarthritis was significantly different from our results. However, the overall average of horizontal angles revealed by Pamukcu et al.[9] was close to our results.

In a study by Wangan et al.,[15] the horizontal inclination angle was found as 22.55° on the right side, and 20.01° on the left. The difference on each side was found as statistically significant. Our results are alike on the right side, but differ on the left with no significant difference. This difference can be attributed to the population difference. Also, a difference as such can arise from the fact that we conducted our measurements on the axial images of CT scans, but Wangan et al.[15] conducted measurements on dry mandibles. This may lead to a discrepancy between the coronal planes drawn on CT image vs imaginary plane in reference to dry bones.

Sertel Meyvacı et al.[16] measured the angle between the mediolateral axis of condyles to give so-called a "co-co angle" of a control group and a group of patients who had temporomandibular joint disorders. They found the "co-co angle" of the control group to be 137.09°±12.23°. The co-co angle for our research was calculated as 134.26°; which is similar to value reported by Sertel Meyvacı et al.[16] They suggested that the horizontal angle of the condyle is not significantly changed related to temporomandibular joint disorders.

In a study done on to compare the difference of measurements on 2D vs 3D-CT images,[17] the horizontal angles on the right and left sides was found to be significantly different on 2D-CT images, however the significance was disappeared when measurements transferred to 3D models. All of our measurements were done on axial CT images, and no significant difference was found between right and left side. Nevertheless, we suggest that 3D reconstructed models can be combined with 2D images to get a better result and to provide a better spatial anatomy of the temporomandibular joint.

Lee et al.[18] investigated horizontal condylar angle between healthy adults and the patients with unilaterally affected joints. They compared the mean angles of the control groups (23.83°±7.69°), unaffected side of osteoarthritis patients (22.51°±7.72°) and the osteoarthritis side (29.54°±10.54°). No significant difference between the angles of the control patients and the unaffected joints was shown, but the contralateral affected joints had a significantly greater condylar angle. Their mean results of the control and unaffected joint angles were in concordance with our findings. In addition, the fact that they measured the horizontal angles of each side individually met with our design of the research. We suggest that this fact can affect the results since angles between two sides can differ.[19]

Table 2

Results of the measurements according to gender.

	Gender	Mean±SD (°)
Right horizontal (n=100)	M (n=51)	23.32±5.55
	F (n=49)	21.53±5.53
Left horizontal (n=100)	M (n=51)	24.60±6.06
	F (n=49)	22.02±5.52
Right ramus (n=100)	M (n=51)	97.19±6.72
	F (n=49)	97.98±5.68
Left ramus (n=100)	M (n=51)	98.84±7.09
	F (n=49)	98.19±6.87

Table 3

Mean condylar horizontal inclination and condylar ramus angles in different age groups regardless of gender and side.

Age groups	n	Horizontal angle mean±SD (°)	Ramus angle mean±SD (°)
18–40	35	22.74±5.87	99.11±6.16
41–58	33	22.47±5.56	98.19±4.69
59–80	32	23.36±4.98	96.27±5.02

Previous studies compared the condylar morphology and temporomandibular disc abnormalities with the horizontal angle. A statistically significant correlation was shown between disc displacement and larger or smaller horizontal angles.[20] Moreover, the horizontal angle was significantly associated with internal derangement; being increased in patient group.[21,22]

The ramus angle measurement is less widely investigated than the horizontal inclination angle. Ocak et al.[23] measured the angle between the long axis of mandibular condyle and long axis of ramus of mandible on the coronal images. However, we made this measurement on the axial images. We suggest that it would be more appropriate to compare the difference between measurements made on coronal vs axial images of the same individuals.

Knowledge of the condylar angles can help in making more accurate condyle prosthesis and reconstruction models. Temporomandibular joint diseases are mostly preferred to be treated by reconstruction; use of alloplastic prosthesis to replace the condyle is rare and limited to specific cases such as tumor or advanced trauma.[24] Reconstruction is achieved by grafts in which a "neocondyle" is created.[25] Neocondyle positioning is a meticulous process because lack of it may lead to joint disorders. Understanding the condylar angles can help with appropriate positioning of the condylar grafts.

One of the limitations of our study is that the number of participants in our study was limited. Contributing of other hospitals would be useful to draw an average result of mandibular angles for the Turkish population.

Conclusion

We suggest that our results would be useful for condylar reconstructions, protheses, and for to have better understanding in terms interpretations of images after a temporomandibular joint disease or trauma.

Conflict of Interest

The authors declare no conflict of interest regarding the methods and results in this study.

Author Contributions

BEC: Project development, data collection and analysis, editing; CA: Data collection and analysis, manuscript writing.

Ethics Approval

The study was approved by the University of Health Sciences Ankara City Hospital Clinical Research Ethics Committee (No: E2-22-1822) and carried out in accordance with the Helsinki declaration of principles.

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