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# Determination of gender through craniofacial midsagittal bone structure angles: Radiological study

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**Abstract**
**Aim:** *Many of the anatomical structures of the cranium are used for gender determination. The aim of this study is to evaluate the usability of five angles belonging to the bone structure seen from the midsagittal plane with Computerized Tomography (CT) in determining gender.*
**Materials and Methods:** *Retrospectively, midsagittal CT images of 99 male and 101 female, a total of 200 people were examined. Five different angles were measured on the midsagittal bone structure. The results were evaluated statistically.*
**Results:** *It was determined that two angles, Rhinion-Spina Nasalis Anterior- Prosthion angle and Nasofrontal angle, could be used for gender determination with respectively 95.3% and 100% reliability. Rhinion-Spina Nasalis Anterior-Prosthion angle mean 135.75±8.68 degrees in male and 138.31±9.33 degrees in female, nasofrontal angle mean 119.64±10.10 degrees in male and 131.22±10.24 degrees in female were ascertained and the mean of both angles was significantly greater in women.*
**Conclusion:** *Our study shows that the Rhinion-Spina Nasalis Anterior-Prosthion angle and the Nasofrontal angle on the CT midsagittal bone image can be safely used for gender determination in anatomical, anthropometric and forensic studies.*
**Keywords**: *craniofacial bone, midsagittal, angles, determine, gender.*

## Introduction

The skull anatomy is one of the most useful structure for radiological determination of gender. Some cranial measurements can be useful to determine gender[1].

Foramen magnum circumference and area were the best discriminant parameters that could be used to study sexual dimorphism with an overall accuracy of 67% and 69.3%, respectively, in computerized tomography (CT) images[2].

Okkesim et al. were found that all variable of mandibular ramus on cone beam CT models showed a statistically significant difference among the gender in the Central Anatolian Turkish population[3].

The accuracy of gender predicted from the linear measurements and volume of the right and the left maxillary sinuses together was found to be 80.0% in males and 86.7% in females. The overall accuracy of gender prediction was 83.3%[4].

Sharifian et al. showed a significant difference in lateral angle of internal acoustic canal, length of mastoid process and the length to width ratio of mastoid process between women and men. Gender differences found in some temporal bone structures, using computerized tomography scan images in Iranian People[5].

Gowda et al. concluded that CT scan helps in accurate measurements of frontal sinus (especially left anteroposterior length) are valuable in differentiating gender[6].

In a study, it was reported that CT can provide valuable information about the foramen magnum and clivus dimensions and can be reliably used in the field of anthropometric and forensic type in gender determination[7].

Debnath et al. found that bi-zygomatic measurement/facial width can be useful to determine gender with high accuracy in Kanara population in India[8].

In an other study conducted on university students in our country, the nasofrontal angle was found to be 133.16 ± 8.88 degrees in women and 123.85 ± 13.23 degrees in men, but its availability in gender determination was not specified[9].

In this study, the availability of five angles measured on cranial midsagittal CT images, which have not been previously investigated, in gender determination was evaluated.

## Materıals and Methods

Our study is a retrospective study and was conducted on midsagittal CT images of men and women aged 25-40 years interval. In this study, 64-slice CT, Brilliance, Philips equipment was used. Permission of the KKU Non-Interventional Ethics Committee has been obtained for our study (Decision No: 2021.03.17).Our study was conducted on 99 male and 101 female.

Criteria for inclusion: Persons without congenital and acquaired maxillofacial anomaly and who have not undergone maxillofacial surgery, there is no diagnosed cerebral disease, without degenerative osteoarthritis, without maxillofacial and intracranial tumors, people aged 25-40 years.

Criteria for exclusion: those who are not in the mentioned age interval, those who carry the mentioned diseases.

Midsagittal image selection: Midsagittal görüntü seçimi: Crista galli (CG) was used as the common reference point of the face and cranium for midsagittal plan. Sagittal plane crossing CG and vertically bisected a line formed by frontozygomatic sutura on both sides[10].

5 Angle measurements were made using mid saagittal CT images:

**CT 1: Sella Tursica (S)- Nasion (N)- Anterior Nasal Spine (ANS)Angle** (**S-N-ANS):** S-N plane is constructed by joining the mid-point of sella tursica (S) with nasion (N). The nasion is the most anterior point of the frontonasal suture. The anterior nasal spine (ANS) is a protrusion of the maxilla at the base of the nose (Figure 1).

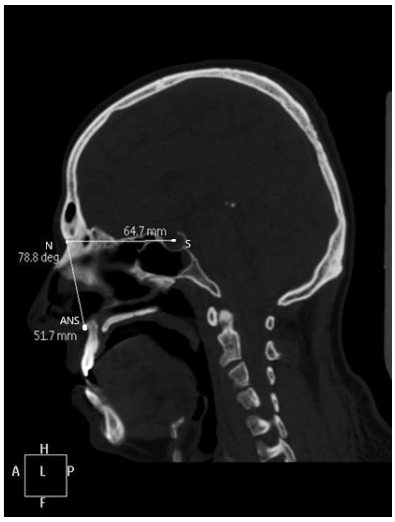



**Figure 1:** S-N-ANS angle

**CT 2: Rhinion (Rh), ANS, Prosthion (Pro) Angle (Rh-ANS-Pro):** Rhinion: a point at the lower end of the median suture joining the nasal bones. Prosthion: point that is the most anterior point in the midline on the alveolar process of the maxilla. The anterior nasal spine (ANS) is a protrusion of the maxilla at the base of the nose (Figure 2).

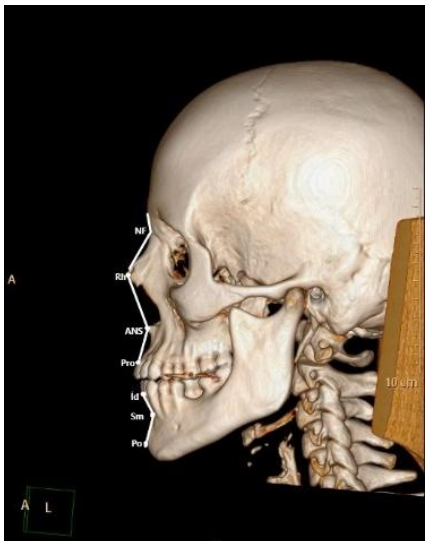



**Figure 2:** Nf, Rh-ANS-Pro Angle and Id-Sm-Po angle

**CT 3:Infradental (Id) point, Supramental (Sm) point, Pogonion (Po) Angle (Id-Sm-Po):** The inferior incisive point (infradental) – situated on the alveolar arch, between the median incisors. Supramental point: deepest anterior point in the concavity of the anterior mandible. Pogonion: mental protuberance (Figure 2).

**CT 4: Nasofrontal Angle (Nf):** The nasofrontal angle is the angle between the forehead & dorsum of the nose (Figure 2).

**Figure 2:** Rh-ANS-Pro Angle and Id-Sm-Po Angle

**CT 5: Maxillo-mandibular angle:** Mandibular plane Gonion-Menthon (Go-Me line) ve maxillar plane (Anterior Nasal Spine–Posterior Nasal Spine) line arasındaki açı. Gonion: midpoint of the mandibular angle is the gonion. Menton: midpoint of the lower edge of the chin. Posterior Nasal Spine (PNS): Posterior nasal spine is created where the two horizontal plates combine at the midline as well as protrudes back from the edge of the hard palate (Figure 3).

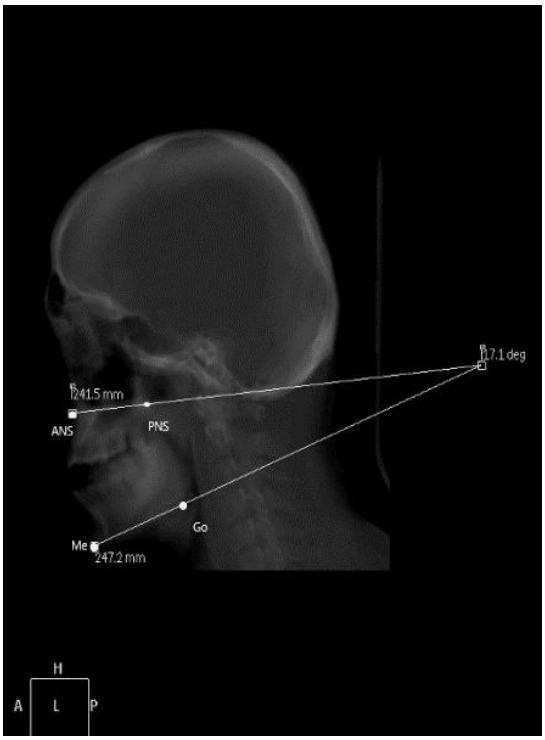



**Figure 3:** Maxillo-mandibuler angle

**Statistical analysis**

It was examined whether the measurements corresponded to the normal distribution. The student-t test was used for gender comparisons in which the measurements corresponded to the normal distribution, and the Man Whitney U test was used for gender comparisons in which the measurements did not correspond to the normal distribution. Descriptive statistics of the measurements were given as mean and standard deviation. ROC curves were created for the diagnostic success of significantly different angles. The consistency between the measurements was assessed by the intraclass correlation coefficient (ICC). For statistical analysis, SPSS (ver. 17) the program was used. $P \leq 0.05$ was taken as the statistical significance level.

**Results**

The mean age was 30.19± 8.25 years for males and 34.50± 8.13 years for females. The averages and standard deviations of the measured angles, as well as the p values in gender comparisons, are given in Table 1.

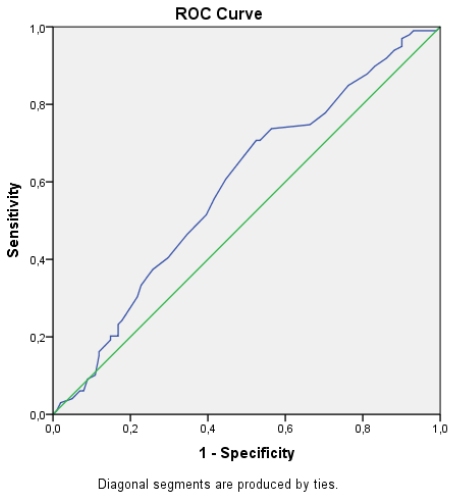
**Table 1.** Averages of angle measurements and gender differences (Degrees)

| | Male (n=99) | Female (n=101) | p value |
|---|---|---|---|
| CT 1 Angle | 90.66± 4.95 | 90.45± 3.75 | 0.740 |
| CT 2 Angle | 135.75±8.68 | 138.31±9.33 | **0.047*** |
| CT 3 Angle | 143.35±7.35 | 143.29±8.34 | 0.957 |
| CT 4 Angle | 119.64±10.10 | 131.22±10.24 | **0.000*** |
| CT 5 Angle | 20.06±6.76 | 21.84±6.27 | 0.055 |

*: p≤0.05

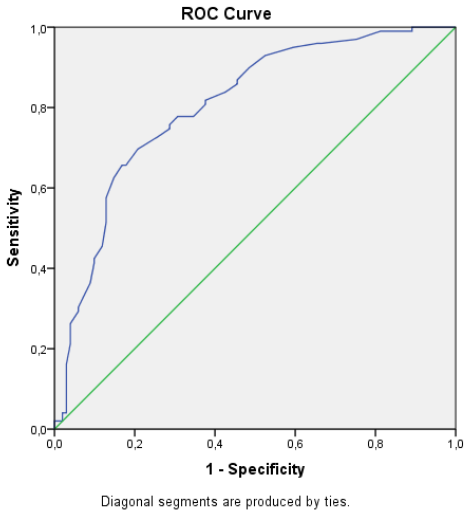
It was found that the usability of the angles in determining gender was significant CT 2 angle (Rhinion, ANS, Prosthion) and CT 4 (Nasofrontal) angle. The reliability of the CT 2 angle in determining the gender was as 95.3%, and the reliability of the CT 4 angle in determining the gender was as 100%.

**Graphic 1:** ROC Curve for Rhinion, ANS, Prosthion Angle




Here, the area under the ROC curve is 0.587 unit square. Women's CT2 angle measurements are 0.587 more likely to have a positive test result than men's angle measurements,which is statistically significant (p=0.035).

**Graphic 2:** ROC Curve for Nasofrontal Angle




Here, the area under the ROC curve is 0.805 unit square. The probability that women have CT4 angle measurements and men have a more positive test result than angle measurements is 0.805, which is statistically significant (p=0.000).
The consistency between the measurements were evaluated by the intraclass correlation coefficient (ICC). As much as 10% of all measurements were measured by the same researcher for the second time and the interclass correlation coefficient was calculated. p<0.05 was considered statistically significant level. The reliability status of the measurements for the CT2 and CT4 angles, which turned out to be statistically significant, is given in Table 2.

**Table 2.** The results of the ICC evaluation of the significant measurements

| Angle | ICC | ICC | P value |
|---|---|---|---|
| | Female | Male | |
| CT 2 Angle | 0.742 | 0.702 | <0.05 |
| CT 4 Angle | 0.826 | 0.942 | <0.05 |

ICC: Intraclass Correlation Coefficient

**Dıscussıon**

Determining gender is one of the most important main elements in idenditification. Many bones in the human skeleton are used to determine gender. It has been reported in the literature that gender determination can be made from the skull by 90%. In cases where bone integrity cannot be fully preserved, where skeletal finds from ancient societies are very fragmentary, in mass disasters such as battlefields or plane crashes, terrorist incidents and explosions, it may become difficult to determine gender due to the fragmentation of the skeleton. Therefore, the evaluation of smaller parts of the skeleton may be important in gender determination. Due to the fact that the skull is more protected from trauma, craniofacial morphometric examinations stand out in this regard[11].

Sharma et al. reported that a significant statistical difference in gender discrimination in the measurements of maxillary sinus volume and anteroposterior diameter performed with CT and informed that the height of the maxillary sinus was the best distinguishing parameter compared to 69.81%[12].Maskey et al. investigated the S-N-ANS angle in a total of 52 people, 24 men and 28 women, and found its mean as 82.4 ± 5.28 degrees. They did not provide information on gender discrimination[13].Zhongtaiet al. reported the mean S-N-ANS angle of 84.38±3.55 degrees in the normal group. Measurements were made on total 39 control group and the averages of female and male are not given separately[14].

In our study, the S-N-ANS angle was determined as 90.66±4.95 degrees in male and 90.45±3.75 degrees in female, and it was understood that it could not be used for gender discrimination.

There is no any research investigating the angle of Rh-ANS-Pro for the normal population.

In our study, the average of this angle was found to be 135.75±8.68 degrees in male and 138.31±9.33 degrees in female, and it was understood that it can be safely used for gender determination.

There is no any research investigating the Id-Sm-Po angle for the normal population. In our study, the average of this angle was found to be 143.35±7.35 degrees in male and 143.29±8.34 degrees in female. However, it has been determined that it cannot be used in gender discrimination.

Okeke et al. reported that, in the Nigeria Anam community, the nasofrontal angle was found to be significantly larger and average 134± 5.7 degrees in female and average 131±7.1 in male, but no information was provided about the gender determination[15].

In their study Polat et al. found that the nasofrontal angle 124.27 ± 11.96 degrees in male, and 133.73 ± 10.62 degrees and significantly larger in female, no gender determination information was provided[16].

In our study, the nasofrontal angle was found to be on average 119.64±10.10 degrees in male and 131.22±10.24 degrees in female, which is significantly larger in women and it was revealed that it can be safely used for gender determination.

Abuhijleh et al. showed that gender significantly influences the gonial angle and has great potential to be used as a forensic tool in gender determination[17].

In their study Ganiger et al. reported that the maxillomandibular angle average of 23.43±4.09 degrees in adults and did not report a separate average for male and female, no gender determination information was provided[18].

In our study, the average maxillo-mandibular angle was found to be 20.06±6.76 degrees in male and 21.84±6.27 degrees in female, and it was understood that this angle could not be used in the gender determination.

**Conclusion**

In recent years, a database can be obtained from the remains of corpses by determining the gender with the help of CT in forensic medicine.In particular, the use of CT in autopsy examinations has become widespread.

Therefore, the finding that the Rhinion- Spina Nasalis Anterior- Prosthion angle and Nasofrontal angle specified in our study can be used as auxiliary anthropometric angle measurements in determining gender will contribute to the literature on this issue.

**Acknowledgments**

**Conflict of interest statement**: The authors declare no conflict of interests

**Consent for publication:** All authors approved of this manuscript and this submission.

**Ethical approval:** Permission of the KKU Non-Interventional Ethics Committee has been obtained for our study (Decision No: 2021.03.17).

**References**

1. Di Vella G, Campobasso CP, Dragone M, Introna F Jr. Skeletal sex determination by scapular measurements. Bollettino della Societa Italiano di Biologia Sperimentale 1994;70:299-305. https://www.academia.edu/68056585/Skeletal_sexdetermination_by_scapular_measurements
2. Uthman AT, Al-Rawi NH, Al-Timimi JF. Evaluation of foramen magnum in gender determination using helical CT scanning, Dentomaxillofacial Radiology 2012;41 (3):197-202. doi: 10.1259/dmfr/21276789
3. Okkesima A, Sezen Erhamzab T. Assessment of mandibular ramus for sex determination: Retrospective study. Journal of Oral Biology and Craniofacial Research 2020;10(4):569-572. doi: 10.1016/j.jobcr.2020.07.019
4. Prabhat M, Rai S, Kaur M.et al. Computed tomography based forensic gender determination by measuring the size and volume of the maxillary sinuses. Journal of Forensic Dental Sciences 2016;8(1):40-46. doi: 10.4103/0975-1475.176950
5. Sharifian H, Qorbanisani M, Tefagh G et al. Assessment of gender differences in temporal bone anatomy using computerized tomography scan ımages in Iranian people. Feyz 2019;23(1): 83-88. http://feyz.kaums.ac.ir/article-1-3694-en.html
6. Gowda SN, Rachegowda N, Sakalecha AK et al. Determination of gender based on frontal sinus dimensions using multi-detector computed tomography. Journal of Clinical and Biomedical Sciences 2021;11(2):72-78.http://www.jcbsonline.ac.in/Articles/Volume11_Issue2/Original%20Article%2002.pdf
7. Bayrak S, Göller Bulut D. Assessment of foramen magnum and clivus for estimation of age and gender using cone-beam CT. Atatürk Üniversitesi Diş Hekimliği Fakültesi Dergisi 2019;29(2):244-251.https://dergipark.org.tr/tr/pub/ataunidfd/issue/44091/482950
8. Debnath MS, Sharma D, Kotian RP, Dsouza B. Estimation of gender accuracy of an ındividual by zygomatic bone measurement using multi-detector computed tomography scan in Kannada population - a forensic study. International Journal of Health Sciences & Research 2019;9(9):65-69.https://www.ijhsr.org/IJHSR_Vol.9_Issue.9_Sep2019/11.pdf
9. Uzun A, Ozdemir F. Morphometric analysis of nasal shapes and angles in young adults, Brazilian Journal of Otorhinolaryngology 2014;80(5):397-402. doi: 10.1016/j.bjorl.2014.07.010
10. Kim TY, Baik JS, Park JY et al. Determination of midsagittal plane for evaluation of facial asymmetry using three-dimensional computed tomography. Imaging Science in Dentistry 2011; 41:79-84. doi: 10.5624/isd.2011.41.2.79
11. 11. Durum Polat Y, Tellioğlu AM, Şahmelikoğlu AG et al. Cinsiyet tayininde maksiller ve frontal sinus çaplarının kullanımı: hangisi daha önemli?

Cerrahpaşa Medical Journal 2020; 44(1):27-34. doi: 10.5152/cjm.2020.19013

12. Sharma SK, Jehan M, Kumar A. Measurements of maxillary sinus volume and dimensions by computed tomography scan for gender determination, Journal of The Anatomical Society of India 2014;63:36-42. doi:10.1016/j.jasi.2014.04.007
13. Maskey S, Shrestha R. Cephalometric approach to vertical facial height. Orthodontic Journal of Nepal 2019;9 (1):54-58. doi: 10.3126/ojn.v9i1.25692
14. Zhongtai Y, Xue X, Ahmatjian A.et al. The craniofacial morphology in adult patients with unoperated ısolated cleft palate. Bone Research 2013;2:195-200. doi: 10.4248/BR201302008
15. Okeke C, Omaballa T. Angular photogrammetric analysis of facial profile of Igbos of Anam Community of Nigeria Rev Arg de Anat Cli 2020;12(2):90-97. doi: 10.31051/1852.8023.v12.n2.27517
16. Polat S, Kabakci AG, Cevik Yet al. Facial angle profiles in Turkish healthy population. Journal of Evolution of Medical and Dental Sciences 2020;9 (14):2278-4748. doi: 10.14260/jemds/2020/258
17. Abuhijleh E, Warreth A, Qawadi M.et al. The open dentistry journal mandibular gonial angle measurement as a predictor of gender-a digital panoramic study. The Open Dentistry Journal 2019;13:399-404. doi:10.2174/1874210601913010399
18. Ganiger CR, Krishna Nayak US, Cariappa KU et al. Maxillomandibular plane angle bisector (mm) adjunctive to occlusal plane to evaluateanteroposterior measurement of dental base. The Journal of Contemporary Dental Practice 2012;13(4):539-544.doi: 10.5005/jp-journals-10024-1182