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Research Article

"MEASURE IT RIGHT"- MANDIBLE IN FORENSICS AS AN AID IN GENDER DETERMINATION: A RETROSPECTIVE 3D CONE BEAM COMPUTED TOMOGRAPHIC STUDY

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A B S T R A C T

The identification of skeletal remains is of paramount importance in medico-legal investigations and anthropological works. Pelvis and skull were the most often investigated skeletal components for gender determination. Various parameters in the Mandible can be considered as a valuable tool in gender determination since it possesses resistance to damage and disintegration processes. Presence of a dense layer of compact bone makes it very much durable and well preserved than many other bones.

Aims and Objectives: To record and infer various parameters in the archived Cone Beam Computed Tomographic images of mandible of males and female subjects which would benefit in effective sex determination.

Materials and Methods: A retrospective study was conducted by using 100 archived CBCT images of patients acquired using promax 3D Mid ProFace. Images of 50 males and 50 female patients whose age ranged between 18-60 years were retrieved and various mandibular parameters which included

- Maximum breadth of the ramus.
- Minimum breadth of the ramus.
- Height of the condyle.
- Height of the coronoid.
- Projective height of ramus
- Gonial angle
- Inter Condylar distance
- Inter Coronoid distance
- Shapes of the chin were measured in both right and left sides using Romexis software.

Results: There was a statistically significant difference found in the maximum ramus breadth, height of the coronoid, height of the condyle, projective height of the ramus, with their mean values 53.49 ± 0.76 mm, 66.42± 0.44mm 73.01±1.46mm and 69.08±1.15 in adult males, respectively and 35.25±1.29mm, 55.02±0.71mm and 63.82± 0.85mm and 56.41±0.49in adult females, respectively, there was three different types of chin shapes observed in both the sexes There was no significant difference was found in the intercondylar distance, intercoronoid distance, mandibular angle of males and females. The parameters used for the present study gave an overall 95.1% accuracy in determining the sexual dymorphism using mandible.

Conclusion: The mandibular parameters like maximum ramus breadth, height of the coronoid, height of the condyle, projective height of the ramus, gonial angle can be used effectively to determine gender.

INTRODUCTION

The identification of skeletal remains is of paramount importance in medico-legal investigations and anthropological works. Sex determination using human skeletal remains is a critical problem in forensic study. Bones are an important tool for determining the age, sex and stature of an individual and thus assist in establishing the identity in a medico legal cases and in identification during mass disasters. These osteometric studies helps in establishing the process of evolution, race and demographic profile.[2] By sex determination, the complexity of identification is scaled down. If the gender of human skeletal remains is established first, then further investigations like estimations of both age and stature can be confirmed with ease. It is widely accepted that the pelvis exhibits the greatest sexual dimorphism[3].

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The eye of forensics has witnessed various mass disasters and natural calamities where skeletal remains were the basis for establishing the identity. In certain worst case scenarios there were few bones or parts of bones were submitted to the forensic investigators for identification.. Pelvis and skull were the most often investigated skeletal components for gender determination. Various parameters in the Mandible can be considered as a valuable tool in gender determination since it possesses resistance to damage and disintegration processes. Presence of a dense layer of compact bone makes it very much durable and well preserved than many other bones.

The mandible may be considered as second most sexually dimorphic bone [4].The mandible is the most durable facial bone that retains its shape better than other bone in the body [2][6] [7] . In mass disasters it can retain its shape better than other bone and commonly resist post mortem damages and form an important source of information about sexual dimorphism [2,7].The mandible has a horizontally curved body that is convex forwards, with two broad rami which bear the coronoid and condyloid processes.

Normally morphological and metric methods are used to determine the sex of a mandible. Male and female mandibles are distinguished by general size [8] , chin shape [4] [10] , gonial angle [9] [10] .In general, the male mandibles are large, slightly more robust with prominent muscular attachment sites than the female mandibles. The present study is conducted to assess the sexual dimorphism in the few metric and morphological parameters in determination of the sex using CBCT.

MATERIALS AND METHODS

This retrospective study was conducted by obtaining 100 archived CBCT images of patients acquired using Planmeca Promax 3D Mid Pro Face machine. Images of 50 males and 50 female patients were retrieved and both the right and left sides were assessed for various mandibular parameters. The study population consisted of patients whose age ranged between 16-70 years who were dentulous. CBCT images of individuals who had any type of developmental disturbance, pathologic condition or mandibular fractures in the jaw region and images with completely edentulous ridges were excluded from the study. CBCT images were obtained retrospectively using the following parameters: 54- 90 kVp, 8-15 mA, acquisition time pulse- 5 to 12 seconds, reconstruction time 62 seconds, voxel size 0.3 mm.

Various mandibular parameters which were used to asses gender included Maximum breadth of the ramus, Minimum breadth of the ramus, Height of the condyle, Height of the coronoid, Projective height of ramus, Gonial angle, Inter Condylar distance, Inter Coronoid distance and Shapes of the chin were measured in both right and left side on sagittal view using Romexis software. Based on the comparative analysis of the above mentioned parameters results were concluded.

Maximum ramus breadth: The distance between the most anterior point on the mandibular ramus and a line connecting the posterior most point on the condyle (Figure-1).

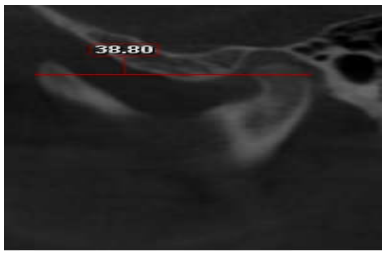


Figure 1

Minimum ramus breadth: Smallest anterior–posterior diameter of the ramus. (Figure-2).

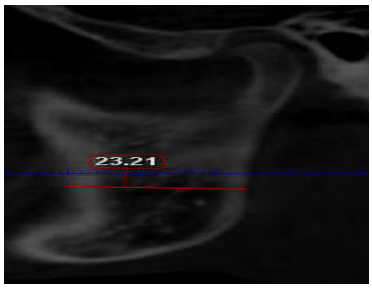


Figure 2

Condylar height: Height of the ramus of the mandible from the most superior point on the mandibular condyle to the inferior border of the mandible.(Figure-3)

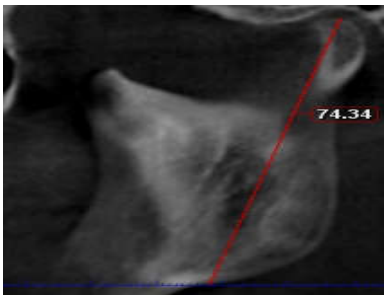


Figure 3

Projective height of ramus: Projective height of ramus is maeasured between the highest point of the mandibular condyle and lower margin of the base of the mandible. (Figure-4)

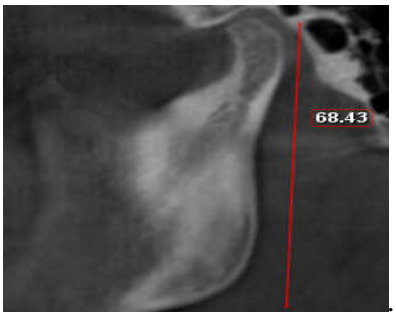


Figure 4

Coronoid height: Projective distance between coronion and lower border of the mandibular bone (Figure-5)

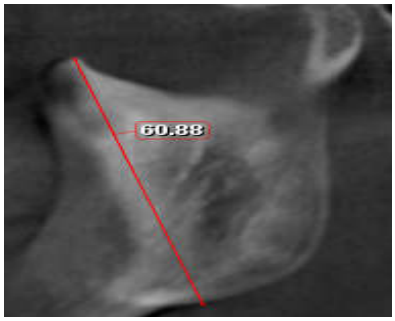


Figure 5

Gonial Angle: The gonial angle was assessed by tracing a tangential line drawn to the lower border of the mandible and another tangential line drawn to the distal border of the ramus on each side. The intersection of these lines formed the gonial angle. The gonial angle measurement in both sides was accomplished using 3D Panaromic view (Figure-6)

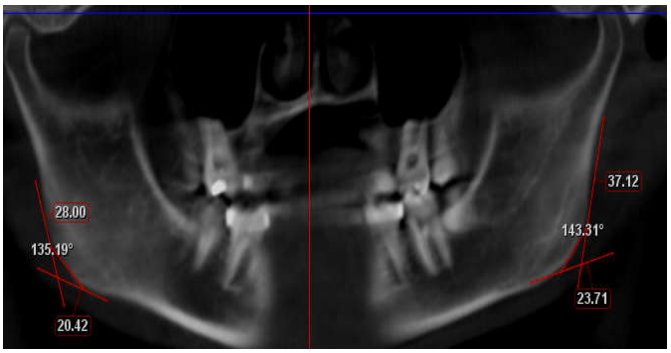


Figure 6

Intercondylar distance*:* is the straight distance between the most lateral points on the two condyles

Intercoronoid distance: is the straight distance between the most lateral points on the two coronoids. The intercodyar distance and intercoronoid distance were recovered using the 3D axial planes. (Figure-6)

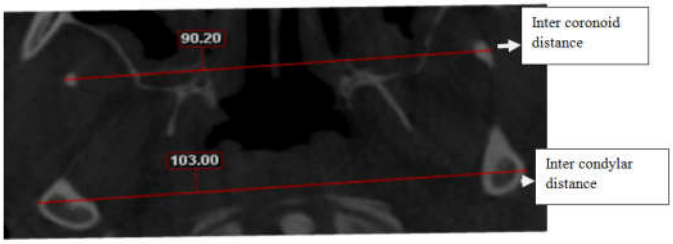
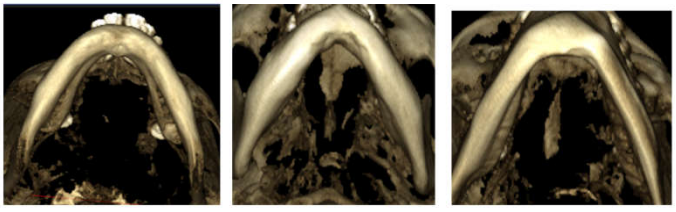


Figure 6

Chin Shape: The details regarding the chin shapes was evaluated using the 3D reconstruction view. We were also able to observe that the lateral aspect of the angle of the mandible in males exhibited a rough or rigid appearance whereas In females the angle of the jaw is often more rounded and gracile in construction. (Figure-7)



U Shape V Shape Square Shape

Figure 7

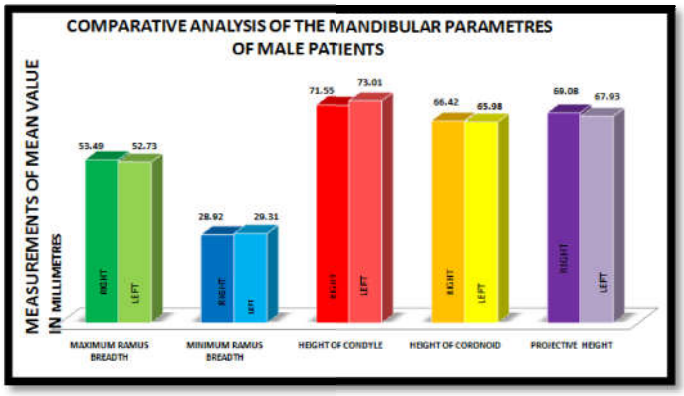
RESULTS

In our study done in archived images 50 males and 50 females patients, On analysis of various parameters in male patients between the right and left side there was only minor differences observed in terms of few millimetre in regards with all the parameters with respect to the sides (Graph 1) [TABLE 1]. Similarly females patients also revealed not much of differences in their values when compared with both sides (Graph 2).

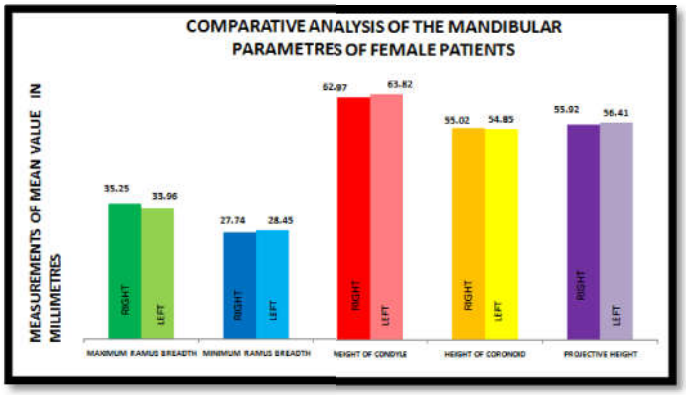
Master Chart

MEAN VALUES OF MANDIBULAR PARAMETERS IN MILLIMETERS			
MAXIMUM RAMUS BREADTH	MALES	FEMALES	P VALUE
RIGHT SIDE	53.49	35.25	0.048
LEFT SIDE	52.73	33.96	0.013
MINIMUM RAMUS BREADTH			
RIGHT SIDE	28.92	27.74	0.432
LEFT SIDE	29.31	28.45	0.127
HEIGHT OF CONDYLE			
RIGHT SIDE	71.55	62.97	0.0348
LEFT SIDE	73.01	63.82	0.0367
HEIGHT OF CORONOID			
RIGHT SIDE	66.42	55.02	0.014
LEFT SIDE	65.98	54.85	0.032
PROJECTIVE HEIGHT			
RIGHT SIDE	69.08	55.92	0.049
LEFT SIDE	67.93	56.41	0.043
INTERCONDYLAR DIST	103.3	89.62	0.721
INTERCORONOID DIST	102.08	89.02	0.736
GONIAL ANGLE IN DEGREES			
RIGHT SIDE	145.05 DEGREES	142.05 DEGREES	0.047
LEFT SIDE	143.81 DEGREES	144.72 DEGREES	0.044

P Value less than 0.05 is considered significant and those parameters with significant p value is denoted in red colour.



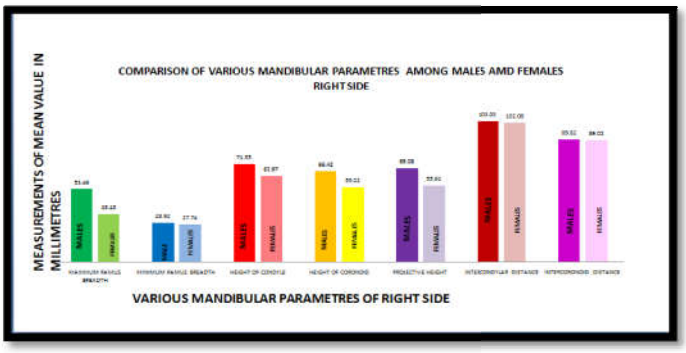
Graph 1



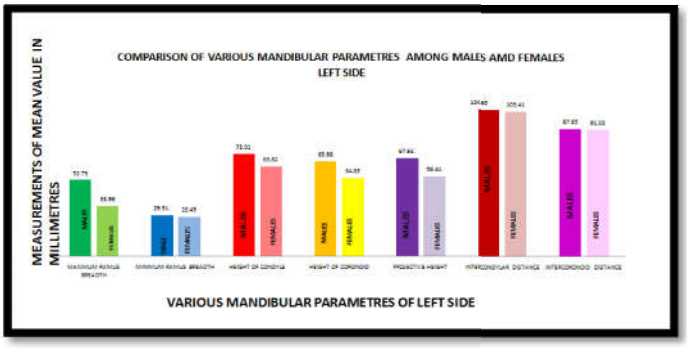
Graph 2

On comparative assessment of various mandibular parameters like maximum ramus breadth, height of condyle, height of

coronoid and projective height of ramus was significantly high in males when compared with that of females in both the right and the left sides (Graph 3 & 4). The other parameters like minimum ramus breadth, intercondylar distance and intercoronoid distance did not exhibhit much of difference between the males and females and furthermore between both the sides.

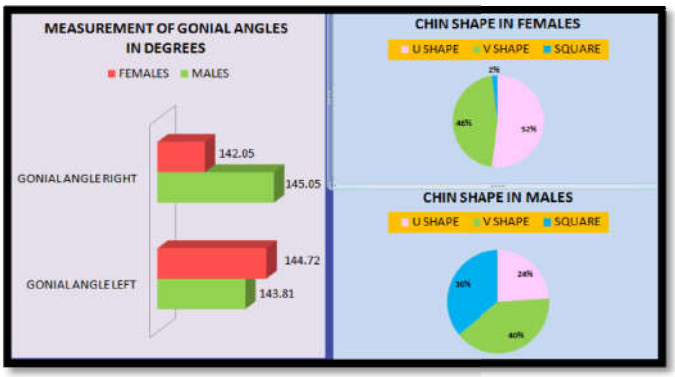


Graph 3



Graph- 4

When gonial angle assessment was carried out the gonial angle in males ranged between 145.05 ^{0} to 143.81^{0} and whereas in females it was found to be 144.72^{0} to 142.05^{0}.The marked observation in gonial angle measurement was the gonial angle of the right side was high when compared with the left side in male patients but it was vice versa in terms of female patients(GRAPH-5)



Graph 5

Chin Shapes

In our study three distinct chin shapes were observed. In females U shaped chin was found in 52% followed by V shaped chin 48% and Square shaped chin in only 2% of the cases. In males V shaped chin was found in 40%, Square shaped chin in 36% and U shaped chin in 24% (Chart -5)

DISCUSSION

Forensic dentistry utilizes various methods for assessing sexual dimorphisms and authentic identification of missing people through skeletal remains. Such estimation can be made using anthropometric measurements in the jaw with the aid of Vernier calipers. The mandible is one of the strongest and most durable skull bones in humans with a high degree of sexual dimorphic characteristics.[24] This study describes an osteometric approach using mandibular measurements to estimate sex in a Indian population; such a model could be used as an auxiliary tool to predict gender in forensic dentistry.

Samantha k *et al* in 2016 [31] used digital orthopantomographs to determine the sex of the individual by measuring the mandibular ramus and concluded that the ramus parameters can be used as a valuable tool for gender determination. As per a morphometric study done by Maneesha Sharma *et al*[32] in the Indian population concluded that the length of the body of the mandible and the minimum ramus breadth were significant high in males than females. M. Shahabi *et al* in 2009[33] did an OPG study to evaluate the existence of any differences in the intercondylar distance among the males and females and found that there was no differences in the intercondylar distance existed between the males and females patients which is in coincidence with our study.

Williams BA, Rogers *et .al* in their OPG study done in 2009 found out there were variations in gonial angle of males and females which is in coincidence with our study and furthermore in our study we were able to conclude that gonial angle of the right side was high when compared with the left side in male patients but it was vice versa in terms of female patients

Naira F, Deana-*et al* -2006 in their morphometric study in Brazilian population concluded that the square shaped chin was attributed to the male patients whereas the V shaped chin was predominantly seen in female patients. But in our study done in Indian population, we were able to identify three distinct chin shapes. In females U shaped chin was found in 52% followed by V shaped chin 48% and Square shaped chin in only 2% of the cases. In males the V shaped chin was found in 40%, Square shaped chin in 36% and U shaped chin in 24%.

Kharoshan *et al* In 2010 evaluated six mandibular measurements in CT images of the Brazilian individuals and found greater mean values in males for three variables like bicondylar breadth, gonial angle and bicoronoid breadth. In our study gonial angle measurement along with four other parameters were significant in determining gender. The intercondylar distance and intercoronoid distance was not sttistically significant in gender determination. [12] These above variables assessed showed 95.1% accuracy in sex estimation, a rate with great reliability when compared with those found in the literature. Iscan *et al* in 1999 found an accuracy of 84.1% (for an association between the cranium and mandible) and 83.7% (skull) in a Japanese population. The rates were 82% to 86% for jaws and skull, respectively, in White South Africans. [25] In a study of black South Africans, Kieser and Groeneveld in 1986 found a 91% accuracy rate for the maxilla and mandible combined and 78% for Gonial angle. The lower jaw bone is frequently found among unidentified remains and can provide accuracy rates of 80% plus. [26]

Several studies have used CT images involving other bony structures to analyze sexual prediction. Uthaman *et al* in 2012[27], using measurements of the maxillary sinus on CT images, reported an accuracy rate of 73.9% and showed viable results for sex estimation. Uthmann *et al*.[28]evaluated the accuracy and reproducibility of the foramen magnum and other cranial measurements in sexual classification and found an accuracy rate of 90.7% for the identification of males and 73.3% for females.

The present study carried out using different mandibular measurements made on 3D CBCT images revealed a high accuracy rate (95.1%) for sexual prediction, suggesting that such images can be used for effective and accurate anthropometric measurements. An important issue to consider is that the presence of high-density materials in the FOV may degrade the image quality and compromise CBCT-based measurements, although this is not the case in this study. Gamba *et al* in 2014 demonstrated that image artifacts arising from metallic restorations have a negative influence on the reliability of orthodontic measurements. Current studies comparing osteometric and tomographic measurements confirm that CBCT images can be used efficaciously for sexual prediction in forensic dentistry, application aimed at achieving human identification of an unknown individual.[30]

In a first CBCT study done by Dr. Saraswathi Gopal, K., *et al* in 2016 various mandibular parameters were analysed and it was evident in their study that parameters like maximum breadth of the ramus, minimum breadth of the ramus, height of the condyle, height of the coronoid and projective height of the ramus were found to have a significant difference among the gender which was in correlation with our present study.

CONCLUSION

Throughout history, dental forensics has played a major role in identification of human remains in crime, abuse and mass disasters. As dental professionals, we can continue to play a key role by maintaining quality records such as CBCT data's of each patient. These days CBCT is gaining more popularity over the other conventional radiographic techniques because of lesser radiation exposure, better accuracy thus it could widen frontiers in the field of forensics. One such frontier would be analyzing the mandibular parameters in gender determination. Thus the outcome of the present study proves certain mandibular parameters can be effective in determining the gender.

References

1. Dr. Saraswathi Gopal, K., Dr. J.K. Singh Kshatri, and Dr. Mahesh Kumar, P. Sex determination with mandibular ramus – a retrospective study based on cone beam computer tomography .*International Journal of Information Research and Review Vol. 03, Issue, 05, pp. 2328-2329, May, 2016*
2. Singh, R., Mishra, S.R.., Sushobhana, Passey, J., Kumar, P., Singh, S., Sinha, P. and Gupta, S. (2015) Sexual Dimorphism in Adult Human Mandible of North Indian Origin. *Forensic Medicine and Anatomy Research*, 3, 82-88.
3. Scheuer, L. (2002) Application of Osteology to Forensic Medicine. *Clinical Anatomy*, 15, 297-312.
4. Giles, E. (1964) Sex Determination by Discriminate Function Analysis of the Mandible. *American Journal of Physical Anthropology*, 22, 129-135.
5. Hu, K.-S., Koh, K.-S., Han, S.-H., Shin, K.-J. and Kim, H.-J. (2006) Sex Determination Using Nonmetric Characteristics of the Mandible in Koreans. *Journal of Forensic Sciences*, 51, 1376-1382.
6. Balci, Y., Yavuz, M.F. and Cağdir, S. (2005) Predictive Accuracy of Sexing the Mandible by Ramus Flexure. *HOMO-Journal of Comparative Human Biology*, 55, 229-237.
7. Kim, H.J., Lee, H.Y., Chung, I.H., Cha, I.H. and Yi, CK. (1997) Mandibular Anatomy Related to Sagittal Split Ramus in Koreans. *Yonsei Medical Journal*, 38, 19-25.
8. Ongkana, N. and Sudwan, P. (2009) Gender Difference in Thai Mandibles Using Metric Analysis. *Chiang Mai Medical Journal*, 48, 43-48.
9. Aitchison, J. (1963) Sex Differences in Teeth, Jaws, and Skulls. *Dental Practice*, 15, 52-57.
10. Ongkana, N. and Sudwan, P. (2010) Morphologic Indicators of Sex in Thai Mandibles. *Chiang Mai Medical Journal*, 49, 123-128
11. de Oliveira Gamba T, Alves MC, Haiter-Neto F, Mandibular sexual dimorphism analysis in CBCT scans, *Journal of Forensic and Legal Medicine* (2016), doi: 10.1016/ j.jflm.2015.11.024.
12. Kharoshah MA, Almadani O, Ghaleb SS, Zaki MK, Fattah YA. Sexual dimorphism of the mandible in a modern Egyptian population. *J Forensic Leg Med*. 2010 May; 17(4):213–15.
13. Saini V, Srivastava R, Rai RK, Shamal SN, Singh TB, Tripathi SK. Mandibular ramus: an indicator for sex in fragmentary mandible. *J Forensic Sci*. 2011 Jan; 56(1):13-6.
14. Steyn M, Iscan MY. Sexual dimorphism in the crania and mandibles of South African whites. *Forensic Sci Int.* 1998 Nov; 98(1-2):9-16.
15. Brough AL, Bennett J, Morgan B, Black S, Rutty GN. Anthropological measurement of the juvenile clavicle using multi-detector computed tomography affirming reliability. *J Forensic Sci*. 2013 Jul; 58(4):946–51.
16. Cevidanes LH, Bayley LJ, Tucker GR Jr, Styner MA, Mol A, Phillips CL, *et al*. Superimposition of 3D cone-beam CT models of orthognathic surgery patients. *Dentomaxillofac Radiol*. 2005 Nov;34(6):369-75.
17. Uthman AT, Al-Rawi NH, Al-Naaimi AS, Al-Timimi JF. Evaluation of maxillary sinus dimensions in gender determination using helical CT scanning. *J Forensic Sci.* 2011 Mar; 56(2):403-8.
18. Uthman AT, Al-Rawi NH, Al-Timimi JF. Evaluation of foramen magnum in gender determination using helical CT scanning. *Dentomaxillofac Radiol.* 2012 Mar; 41(3):197-202.
19. Mozzo P, Procacci C, Tacconi A, Martini PT, Andreis IA. A new volumetric CT machine for dental imaging based on the cone-beam technique: preliminary results. *Eur Radiol* 1998 Jun;8(9):1558-64.
20. Marmulla R, Wörtche R, Mühling J, Hassfeld S. Geometric accuracy of the NewTom 9000 Cone Beam CT. *Dentomaxillofac Radiol*. 2005 Jan;34(1):28-31.
21. Biwasaka H, Aoki Y, Tanijiri T, Sato K, Fujita S, Yoshioka K, *et al*. Analyses of sexual dimorphism of

contemporary Japanese using reconstructed three dimensional CT images--curvature of the best-fit circle of the greater sciatic notch. *Leg Med*. 2009 Apr; 11(1): 260-2. Manuscript Accepted Accepted Manuscript 13

22. Angel JS, Mincer HH, Chaudhry J, Scarbecz M. Cone-beam computed tomography for analyzing variations in inferior alveolar canal location in adults in relation to age and sex. *J Forensic Sci.* 2011 Jan; 56(1):216–9.
23. Neves FS, Nascimento MC, Oliveira ML, Almeida SM, Bóscolo FN. Comparative analysis of mandibular anatomical variations between panoramic radiography and cone beam computed tomography. *Oral Maxillofac Surg*. 2013 Aug 24. [Epub ahead of print]
24. De Oliveira Gamba T, Alves MC, Haiter-Neto F, Mandibular sexual dimorphism analysis in CBCT scans, *Journal of Forensic and Legal Medicine* (2016), doi: 10.1016/j.jflm.2015.11.024.
25. Iscan MY, Steyn M. Craniometric determination of population affinity in SouthAfricans. *Int J Legal Med*. 1999 Dec; 112(2):91-7.
26. Kieser JA, Groeneveld HT. Multivariate sexing of the human viscerocranium. *J Forensic Odontostomatol.* 1986 Dec; 4(2):41-6.
27. Uthman AT, Al-Rawi NH, Al-Naaimi AS, Al-Timimi JF. Evaluation of maxillary sinus dimensions in gender determination using helical CT scanning. *J Forensic Sci.* 2011 Mar;56(2):403-8.
28. Uthman AT, Al-Rawi NH, Al-Timimi JF. Evaluation of foramen magnum in gender determination using helical CT scanning. *Dentomaxillofac Radiol*. 2012 Mar; 41(3):197-202.
29. Gamba TO, Oliveira ML, Flores IL, Cruz AD, Almeida SM, Haiter-Neto F, Lopes SL. Influence of cone-beam computed tomography image artifacts on the determination of dental arch measurements. *Angle Orthod.* 2014 Mar; 84(2):274-8.
30. Brough AL, Bennett J, Morgan B, Black S, Rutty GN. Anthropological measurement of the juvenile clavicle using multi-detector computed tomography affirming reliability. *J Forensic Sc*i. 2013 Jul; 58(4):946–51.
31. Samatha K, Sujata Mohan Byahatti, Renuka Anand Ammanagi, Praveena. Sex determination by mandibular ramus: A digital orthopantomographic study. 2016 *Journal of Forensic Dental Sciences* June 11, 2017
32. Maneesha Sharma R.K. Gorea Arshdeep Gorea, Abdulwahab Abuderman A morphometric study of the human mandiblein the Indian population for sex determination. *Egyptian Journal of Forensic Sciences* (2016) 6, 165-169
33. M. Shahabi, B. Ramazanzadeh, and N. Mokhber, "Comparison between the external gonial angle in panoramic radiographs and lateral cephalograms of adult patientswith class Imalocclusion," *Journal of Oral Science*, vol. 51, no. 3, pp. 425-429, 2009.

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