Original Research Article

Sexual differentiation based on mandibular parameters utilizing cone beam computed tomography of a sample of Egyptian population

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Abstract

Aim: To assess sexual identification in forensic context over a sample of Egyptian population using osteometric mandibular measurements performed on cone beam computed tomography (CBCT) images.

Materials and methods: The present study comprised of 102 living non-pathological Egyptian CBCT records of mandibles (204 mandibular rami and angles bilaterally) 52 males and 50 females aged 20-70 years. All the patients were scanned with CBCT for various purposes. Six measurements were finished in the jaws on CBCT images: gonial angle (GA), ramus length (RL), minimum ramus breadth (MRBr), gonionegnathion length (GGL), bicondylar breadth (BicBr) and bigonial breadth.

Results: Males had statistically significantly higher mean ramus length, minimum ramus breadth, Bigonial distance, Bicondylar distance and mandibular base length than females. Males showed statistically significantly lower mean ramus angle than females. The significant predictors for gender were: Bicondylar distance, mandibular base length and ramus length.

Conclusion: This study on mandibles of a sample of Egyptian population clearly indicated that the Bicondylar distance, mandibular base length and ramus length have satisfactory potential for determination of sex.

Key words

Forensic, CBCT, Mandible, Sex identification.

Introduction

The skull bone is taken into consideration as the second high-quality after the pelvic bone in sex dedication due to its higher retention of morphological capabilities and its sturdiness to converting environmental conditions. Sexual dimorphism represents a group of morphologic characteristics that differentiate males from females. Craniofacial morphology has inclusive particular characteristics such as dento-alveolar height, have been assessed in various ethnic groups. Other dimorphic elements have been identified relative to the mandibular bone such as the mandibular or gonial angle, the ramus length, the bigonial width, the bicondylar width. Among these indicators, it is far observed that dimorphism is generally more obvious in ramus of the mandible than in the mandibular body. Mandibular ramus can distinguish between sexes because the development of mandibular process and masticatory forces are not the same for males and females which impact the shape of the ramus [1-5].

New strategies, which include medical scanning, are developed constantly, making it possible to revisit the anatomy of the mandible more effectively. At present, computerized or virtual methodologies become a developing trend in forensic anthropology. The introduction of Cone-Beam Computed (CBCT) era in the clinical management of patients has proven valuable in volumetric analysis. So, sex determination using CBCT images seems to have some advantages compared with conventional osteometric approaches [2-4, 6, 7].

Materials and methods

The present study comprised of 102 living non-pathological Egyptian CBCT records of mandibles (204 mandibular rami and angles bilaterally) 52 males and 50 females aged 20-70 years. All the participants were scanned with CBCT for various purposes using a Promax® 3DMid CBCT device (PlanmecaOy, Helsinki, Finland).

The CBCT measurements were achieved using "*PlanmecaRomexis viewer 3.5.1.R"* software with the distance and angle measurement tools. Our mandibular measurements were in compliance with Kharoshah, et al. (2010) [8]. Four of them were measured from the corrected sagittal CBCT images which are ramus angle (**Figure - 1**), ramus length (Ramus-L), Minimum ramus breadth (M-Ramus-Br) and mandibular base length, i.e. gonion–gnathion length (G–G-L) as shown in (**Figure - 2**). Regarding the other two measurements, one was measured from the axial image which is bigonial breadth (BG-Br) **(Figure - 3**). And the other one was measured from the coronal image which is bicondylar breadth (BIC-Br) as shown in (**Figure - 4**).

Figure-1: Mandibular ramus angle measurement in CBCT corrected sagittal cut.

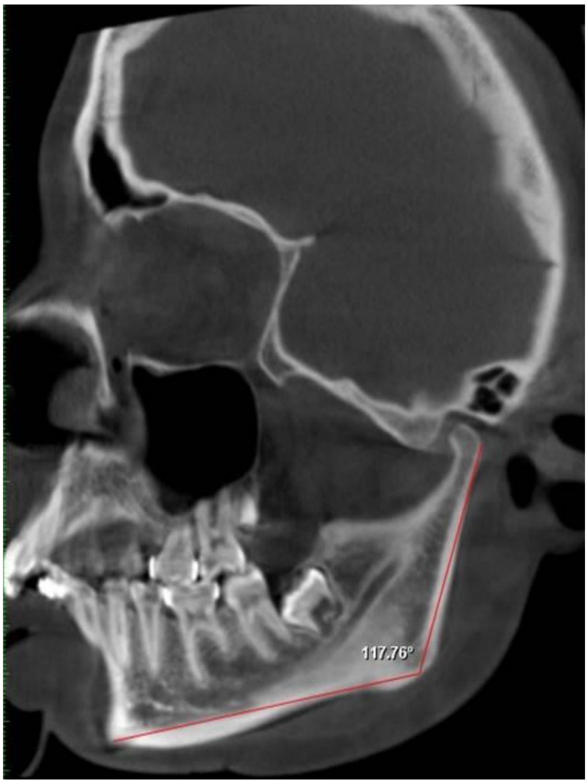

Figure - 2: Mandibular ramus length (Ramus-L), Minimum ramus breadth (M-Ramus-Br) and mandibular base length measurements in CBCT corrected sagittal cut.

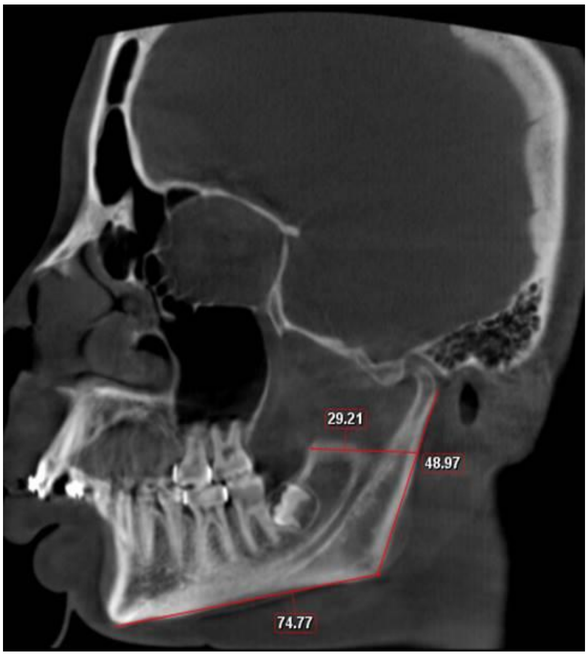

Figure - 3: Mandibular bigonial measurement in CBCT axial cut.

Figure - 4: Mandibular bicondylar measurement in CBCT coronal cut.

The evaluators marked out the 3D locations of the three anatomical landmarks: gonion, condylion, and gnathion. The gonion represented the lower, back, and side point on the outer angle of the mandible, while the condylion represented the most upper and back point of the mandibular condyle. Lastly, the gnathion represented the most low and front point on the profile curvature of the chin. Six measurements were finished in the jaws on CBCT images according to Kharoshah, et al. (2010) [8]: gonial angle (GA), ramus length (RL), minimum ramus breadth (MRBr), gonionegnathion length (GGL), bicondylar breadth (BicBr) and bigonial breadth. The junction of the posterior and lower borders of the mandible forms the gonial angle. The distance between the anatomic landmarks condylion and gonion is the ramus length, the distance between the gonion and gnathion is the mandibular base length and the least width of the mandibular ramus is the minimum ramus breadth. The distance between the most lateral points on the two condyles is the bicondylar breadth. The distance between the right and left gonion is the bigonial breadth.

Image analysis

The axial cut was the starting point to extract the corrected sagittal image. The optimal corrected sagittal image showing the condyle, angle and the anterior curvature of the chin clearly via rotating vertical and horizontal axes of the axial cuts for each side separately. For the bicondylar distance, via scrolling through the coronal cuts. For the bigonial distance, via scrolling through the axial cuts.

Two independent well trained radiologists with experience more than 10 years made all the CBCT measurements after appropriate training and working on the software used in this study *(Planmeca Romexis viewer 3.5.1.R).*

All the CBCT measurements were done twice at two different sessions and the average of the two measurements was considered the final one.

Statistical analysis

Data were presented as mean, standard deviation (SD, median, minimum, maximum and 95% Confidence Interval (95% CI) values. Paired t-test was used to compare between right and left side measurements. Student's t-test was used to compare between males and females. Cronbach's alpha reliability coefficient and Intra-class Correlation Coefficient (ICC) were used to determine inter-observer agreement.

Stepwise discriminant analysis was conducted to predict gender (Male or Female) from the different mandibular measurements. Stepwise statistics revealed the significant predictors which were used to determine the discriminate function. Then group centroids (group means) were calculated, they represent the determinant points for discrimination between males and females. Finally, classification table represented the percentage of accurately classified cases according to the discriminate function.

The significance level was set at $P \leq 0.05$. Statistical analysis was performed with IBM (IBM Corporation, NY, USA) SPSS (SPSS, Inc., an IBM Company) Statistics Version 20 for Windows.

Results

Descriptive statistics

The present study was conducted on 102 subjects; 52 males (51.0%) and 50 females (49.0%). Descriptive statistics of the present study were presented in **Table - 1**. Comparisons between right and left sides revealed non-statistically significant difference between the two sides, so the mean of the two sides was used in further statistical analysis.

Inter-observer agreement

There was very good inter-observer agreement regarding all measures with Cronbach's alpha values ranging from 0.906 to 0.983.

Comparison between males and females

Males showed statistically significantly higher mean ramus length, minimum ramus breadth, Bigonial distance, Bicondylar distance and mandibular base length than females. Males showed statistically significantly lower mean ramus angle than females (**Table - 2**).

Gender estimation

A discriminant analysis was conducted to predict gender (Male or Female). The significant predictors for gender were: Bicondylar distance, mandibular base length and ramus length (**Table - 3**). The discriminate function was:

D = 0.086 ramus length + 0.057 Bicondylar distance + 0.080 mandibular base length – 17.266

The discriminate functions at group centroids (Group means) were 0.742 for males and -0.772 for females.

Classification results revealed that 82.7% of the males were correctly classified while 76.0% of the females were correctly classified according to the prediction equation. Hence, the overall correct classification was 79.4% (**Table - 4**).

Table – 1: Descriptive statistics of the different measurements.

Gender	**Measurement**	**Mean**	**SD**	**Median**	**Minimum**	**Maximum**	**95% CI**	
							Lower bound	**Upper bound**
Male	Ramus length	56.0	5.6	56.8	42.0	66.1	54.5	57.6
	Minimum ramus breadth	24.7	2.6	24.9	18.6	31.2	24.0	25.4
	Bigonial distance	86.6	5.0	87.2	75.0	100.4	85.2	88.0
	Bicondylar distance	114.8	7.4	116.6	99.1	136.0	112.8	116.9
	Ramus angle	122.0	6.2	121.6	110.1	138.8	120.3	123.7
	Mandibular base length	83.4	7.2	84.4	65.5	101.5	81.4	85.4
Female	Ramus length	51.8	4.1	51.2	45.5	61.1	50.6	52.9
	Minimum ramus breadth	23.1	3.2	23.4	16.6	29.8	22.2	24.0
	Bigonial distance	82.5	4.4	82.0	74.0	92.4	81.2	83.7
	Bicondylar distance	106.7	5.6	106.2	96.0	121.6	105.1	108.3
	Ramus angle	125.9	6.7	125.5	114.0	141.6	124.0	127.8
	Mandibular base length	74.8	8.1	75.0	54.0	91.2	72.5	77.1

Table – 2: Mean, standard deviation (SD) values and results of Student's t-test for comparison between males and females.

Measurement	**Males (n=52)**		**Females (n=50)**		***P*-value**
	Mean	**SD**	**Mean**	**SD**	
Ramus length	56.0	5.6	51.8	4.1	<0.001*
Minimum ramus breadth	24.7	2.6	23.1	3.2	0.005*
Bigonial distance	86.6	5.0	82.5	4.4	<0.001*
Bicondylar distance	114.8	7.4	106.7	5.6	<0.001*
Ramus angle	122.0	6.2	125.9	6.7	0.003*
Mandibular base length	83.4	7.2	74.8	8.1	<0.001*

*: Significant at $P \leq 0.05$

Table – 3: Summary of Canonical Discriminant function for predictors of gender.

Predictors	**Unstandardized coefficient**	**Wilk\s Lambda**	***P*-value**
Ramus length	0.086	0.662	<0.001*
Bicondylar distance	0.057	0.652	<0.001*
Mandibular base length	0.080	0.707	<0.001*
Constant	-17.266		

*: Significant at $P \leq 0.05$

Table – 4: Classification results according to the discriminate function of predicting gender from mandibular measurements.

Gender	**Observed**	**Predicted**		**Percentage correct**
		Male	**Female**	
Male	52	43	9	82.7
Female	50	12	38	76.0
Overall percentage				79.4

Discussion

Generally, the cranio-dento-facial size of males is significantly larger than that of females. Sexual differentiation of the cranio-dento-facial width dimensions is most pronounced in the zygoma, the mandibular angle and the condyles. Sexual dimorphism in human mandible morphometrics has been studied extensively. The shape of the chin could be used to differentiate between males and females. The mandible shows several dimorphic characteristics that are obvious in females than in males leading to a higher mandibular angle in women than men [1, 9].

Our sample comprised of individuals in the age ranged from 20 to 70 due to the fact most sex differentiating functions do not come to be surely visible until maturity. Moreover, there were no variations inside the age structure between two sexes, so age- associated changes within the mandibles had been not going to have motivated the effects.

Steady differences have been located among male and female mandibles from various populations of human groups which imply that mandible is one of the most grounded, biggest, hardest and most tough skull bones in humans [2].

Although human sex determination is now better known worldwide, there are few osteometric studies designed for sex assessment in Egyptians. Additionally, there is no formerly systematic researches in the literature have been carried out considering these measurements in this population [8]. The current study used mandibular measurements to estimate sex in a sample of Egyptian population; such a model could be used as an adjunctive tool for sex prediction.

Most of the studies on mandible geometrical measurement have been performed either directly on the wet mandibles from cadavers or on the dry bone collections. With CBCT providing all the eligibility criteria regarding the scanning and reconstruction technology producing highly accurate life size images and the 3D image reconstruction with special softwares [6, 7, 9-11].

Hilgers, et al. (2005) [12] found that all mandibular measurements based on CBCT views were accurate in compliance with the direct physical measurements and intraobserver agreement [9].

In this study, males showed statistically significantly higher mean ramus length, minimum ramus breadth, Bigonial distance, Bicondylar distance and mandibular base length than females. Males showed statistically significantly lower mean ramus angle than females.

A discriminant analysis was conducted to predict gender (Male or Female). The significant predictors for gender were: Bicondylar distance, mandibular base length and ramus length. The discriminate functions at group centroids (Group means) were 0.742 for males and -0.772 for females.

Classification results revealed that 82.7% of the males were correctly classified while 76.0% of the females were correctly classified according to the prediction equation. Hence, the overall correct classification was 79.4%.

Supporting our study, Kharoshah, et al. (2010) [8] detected that three out of the six studied mandibular measurements showed significantly higher mean values in males than in females.

Deng, et al. (2017) [9] demonstrated the metric characterization of the mandible in the central China population to identify the degree of sexual differentiation. All the breadth dimensions analyzed, including Bi-condylar, Bi-gonial, Bi-angular and Bi-mental, were significantly higher in men than in women ($p<0.0001$).

Inconsistent to our study, Saini, et al. (2011) [2] detected that each of the five variables measured on mandibular ramus of the Indian population showed statistically significant sex differences between male and female, concluding that ramus is strong sexual differentiator in this population. Overall discrimination rate using all five variables was 80.2%, with females slightly more accurately determined than males [2].

Measurements of the height of mandibular ramus tend to show higher sexual dimorphism than measurements of body height and breadth. Thus, emphasizing that sex differences are more pronounced in mandibular ramus than body by Loth and Henneberg (1996) [13] and Saini, et al. (2011) [2] which support our findings

On contrary, Dayal, et al. (2008) [14] found mandibular ramus height the best discriminant in their study with 75.8% accuracy. Previously, Franklin, et al. (2006) [15] mentioned that condyle and ramus are the greatest sexual discriminants [2].

Geographic and socio-environmental factors (e.g., nutritional background, weather, diseases, occupation etc.), affect the development and the appearance of bones. It is properly set up that discriminant characteristic derived from one specific population cannot be carried out to every other as magnitude of sex-related differences vary considerably among regional populations. So, there is may be constantly a need to broaden population-particular standards for accurate sex determination from a skeleton deriving from that population. Hence, standards have been established for different populations worldwide [2, 16, 17, 18].

Conclusions

This study on mandibles of a sample of Egyptian population clearly indicated that the bicondylar distance, mandibular base length and ramus length have satisfactory potential for determination of sex.

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