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Age Estimation and Sex Identification Using Digital Panoramic Radiography of the Mandible among the Egyptian Population

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ABSTRACT

Background: Age and sex determination are required for medico-legal and forensic purposes. Since the mandible is the most dimorphic bone in the skull and is frequently found intact, it may be crucial in determining sex. In this context, the abundance of antemortem digital panoramic radiographs could be very helpful in researching and creating population-specific criteria for precise age and sex estimates.

Objective: The current study aimed to evaluate the value of digital panoramic radiographs in age estimation and sex identification among Egyptian population samples.

Methods: This study was conducted on 200 Egyptian participants (103 females and 97 males) aged between 20 and 60 years, who were classified into 4 age groups: Group 1 (20-29), group 2 (30-39), group 3 (40-49), and group 4 (50-60). Six mandibular dimensions were measured by using digital panoramic radiographs, to identify age and sex.

Results: Comparisons among the 4 age groups did not reveal statistically significant differences concerning the studied dimensions, however comparisons between these groups in females and males separately revealed statistically significant differences in some dimensions. The measured dimensions were significantly different between males and females, with greater female mean values in angular measurements and mean values in linear measures. Discriminant function analysis helped to identify sex with an accuracy value of 87%, whereas logistic regression analysis could identify sex with an accuracy of up to 85%.

Conclusion: Mandibular dimensions have a high degree of reliability and applicability for sex identification.

Keywords: Mandibular parameters, Egyptian population, Digital panoramic radiography, Sex and age identification.

INTRODUCTION

Age and sex confirmation play crucial roles in crime investigations and mass disasters where victims' bodies become unrecognizable as a result of mutilation. In addition, it is important for some other medicolegal issues. The person's gender and age at death represent key features leading to identification [(1)].

Over time, in mass disasters, the skull has continued to be useful for creating biological profiles. However, the technical methods must usually be based on the skull's destroyed bones when the full skull is unavailable. In these situations, determining the suspects' sex from their corpse remains depends mainly on the mandible [(2)]. Previous findings have shown that sexual dimorphism in the adult mandible is evident and impacts multiple anatomical areas. According to reports, gonial area, the ramus, and symphysis region are some of the most dimorphic features of mandibular anatomy. Because certain mandibular regions go through age-related remodeling, the pattern of sexual dimorphism may vary with age and could be influenced by other causes and not be seen as a static state [(3)].

Therefore, each morphometric group has different skeletal traits, which highlights the necessity of population-specific osteometric criteria for estimating age and sex [(4)].

Hospitals, medical clinics, and dental clinics now routinely perform dentofacial radiography. A significant portion of the population gets radiographs taken at different points in their lives. Owing to its availability, it is considered a valuable tool in identification [(5)].

The most popular extraoral radiographs that offer the most information on the hard tissue of the maxilla and mandible are panoramic radiographs (orthopantomagram) (OPG), which are also easily preserved and can be kept in a database for years. A calibrated measurement tool was employed in forensic anthropology, and antemortem radiographs are the primary means of positively identifying human remains. Studying sexual dimorphism and estimating an individual's age in particular groups is made possible by the abundance of panoramic radiography [(6)].

Thus, the goal of the current study was to assess the value of six mandibular measurements in estimating age and identifying sex in a sample of the Egyptian population via digital panoramic radiographs.

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MATERIALS AND METHODS

This research was conducted on 200 participants (103 females and 97 males) who were subjected to digital panoramic mandibular images for various diagnostic purposes at the Faculty of Oral and Dental Medicine, Cairo University. After being obtained for a variety of diagnostic reasons, the digital panoramic mandibular images were assessed. The participants were classified into four age groups: **Group 1** (20–29 yrs.), **group 2** (30–39 yrs.), **group 3** (40–49 yrs.) and **group 4** (50–60 years.). For standardization purposes, only radiographs taken on the same panoramic unit by a radiographer were considered.

Inclusion criteria: Good-quality panoramic radiographs without any positioning errors. Adult persons between 20 and 60 years old. Both sexes. Apparently normal growth.

Exclusion criteria: Non-Egyptian origin. Completely edentulous patients. If traumatic or pathological lesions of the mandible were present.

Mandibular measurements: A Planmeca Proline CC panoramic X-ray machine, Helsinki, Finland, was used to take all of the panoramic images. Digital panoramic images obtained in Digital Imaging and Communications in Medicine (DICOM) format were analyzed via the Planmeca Romexis Viewer 2.9.2. R software program with tools for linear and angular measurements once the image has been calibrated to achieve a 1:1 magnification. Images of known age and sex were assessed by one maxillofacial radiologist and one forensic researcher. The following linear mandibular and angular mandibular measurements were taken in centimeters.

1) **Maximum ramus breadth (MRB):** According to **Poongodi *et al.*** [7] the maximum ramus breadth was obtained by measuring the line from below the sigmoid notch of the outer border of the mandibular condyle to the inner coronoid border **(Figure 1)**.

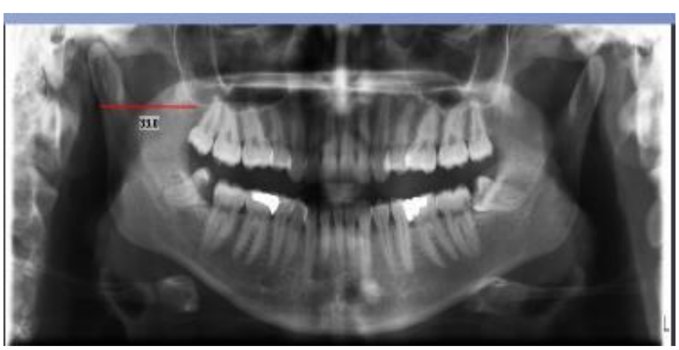

Figure (1): Maximum ramus breadth.

2) **Gonial angle (GA): Poongodi *et al.*** [7] stated that the gonial angle was determined by drawing two lines, one tangent to the mandibular lower border and the other to the condyle posterior border. The gonial angle was established at the junction of these lines **(Figure 2)**.

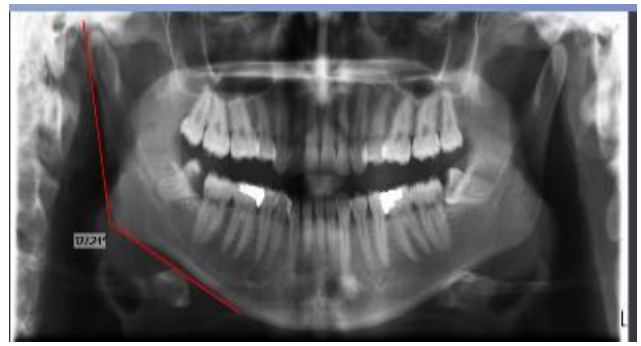

Figure (2): Gonial angle.

3) **Maximum ramus length (MRL):** According to **de Oliveira *et al.*** [8] the maximum ramus length was measured by a line from the superior condylion (Cs), the mandibular condyle's highest point, to the gonion (Go), the outermost point and lateral point where the mandibular ramus and body meet **(Figure 3).**

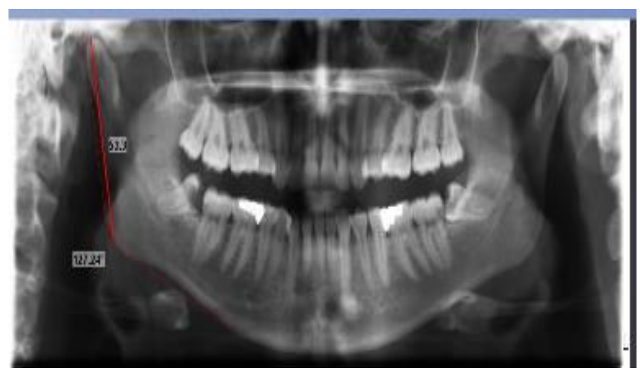

Figure (3): Maximum ramus length.

Marking the point in the bisector of the gonial angle allowed for the identification of the Go point **(Figure 4).**

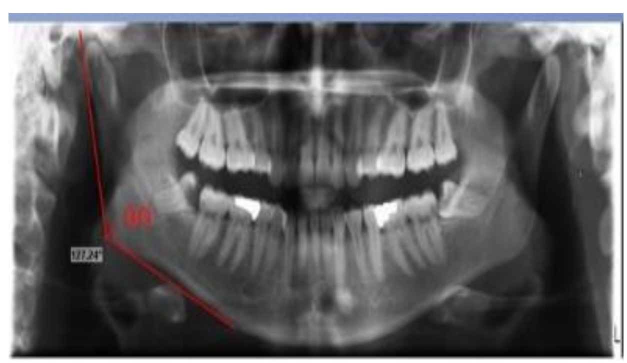

Figure (4): The bisector of the gonial angle used to identify the gonion (GO).

4) **Bigonial width (BGW):**
According to **Leversha *et al.*** [9], the spatial width was measured using a line drawn horizontally between the left gonion and right gonion **(Figure 5).**

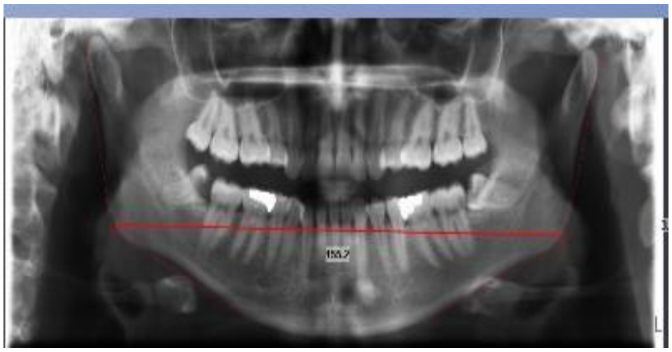

Figure (5): Bigonial width.

5) Antegonial angle (AGA):

According to **Chole *et al.*** [10], two parallel lines were traced to the antegonial region that connects with the deepest part of the antegonial notch to determine the antegonial angle **(Figure 6).**

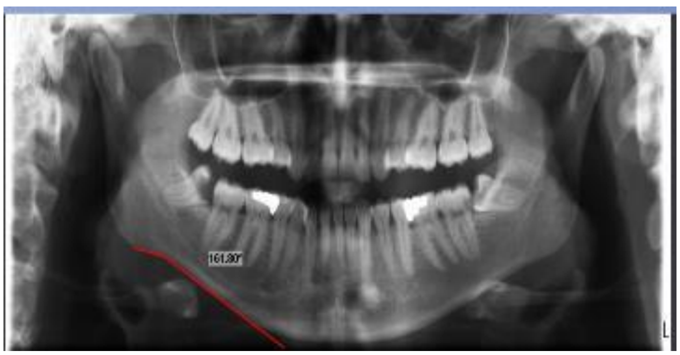

Figure (6): Antegonial angle.

6) Antegonial depth (AGD):

According to **Chole *et al.*** [10] the distance between the deepest part of the notch concavity and a tangent through the inferior border of the mandible, measured along a perpendicular line, is the antegonial depth **(Figure 7).**

All these parameters were measured on the **right side** except for the BGW.

Figure (7): Antegonial depth.

Ethical approval: This study was approved by The Institutional Review Board of The Faculty of Medicine, Cairo University. All procedures in this study involving human participants were in compliance with the ethical requirements of Institutional and/or National Research Committees and with the 1964 Helsinki declaration and its later amendments. Participants in the study provided informed consents.

Statistical analysis

The data were coded and entered into SPSS version 24. The quantitative variables were provided as means, standard deviations, 95% confidence intervals, minimums, and maximums, whereas the categorical variables are reported as frequencies and percentages. Males and females were compared using the Student's t test, and Pearson's correlation coefficient was applied to assess relationships between variables. Stepwise discriminant analysis was used to estimate sex based on mandibular measures, starting with testing mean differences, identifying significant predictors, constructing the discriminant function, calculating group centroids, and evaluating classification accuracy. Logistic regression analysis was also applied to predict sex, with statistical significance set at $P \leq 0.05$.

RESULTS

Among the 200 participants, 103 (51.5%) were females, and 97 (48.5%) were males **(Figure 8)**. The participants were distributed into 4 different age groups regardless of sex (**Figure 9).**

Group 1: 51 participants (25.5%), **group 2:** 52 participants (26%), **group 3:** 50 participants (25%) and **group 4:** participants (23.5%).

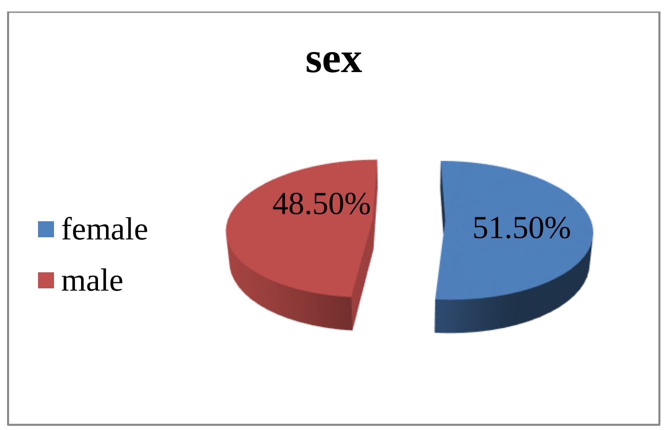

Figure (8): Distribution of the studied samples between both sexes

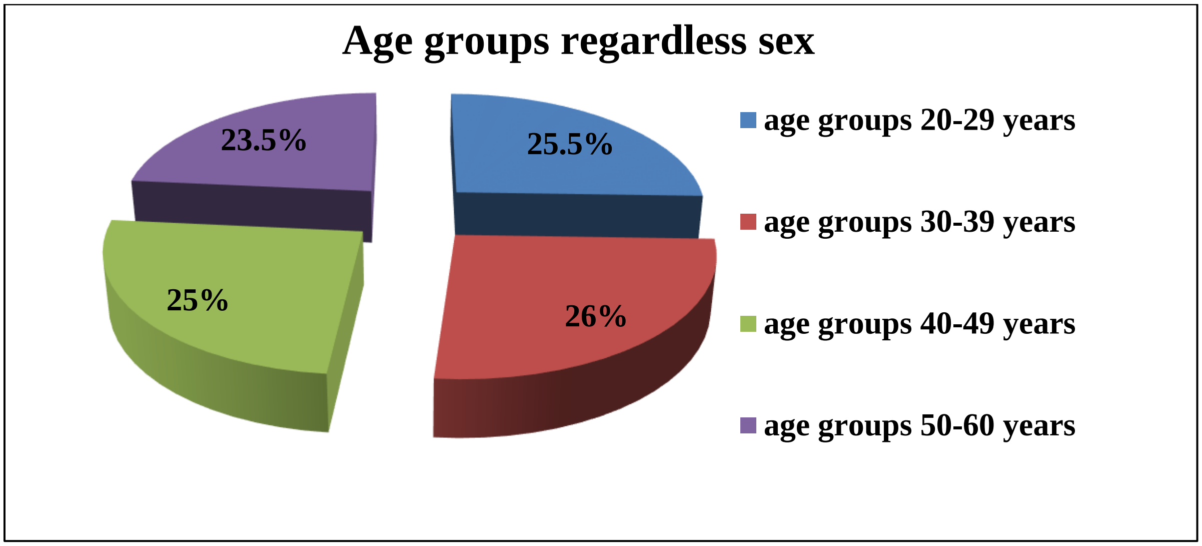

Figure (9): Distribution of the entire studied sample across the 4 different age groups

A comparison of the measured dimensions across the 4 different age groups revealed that there was no statistically difference in the measured dimensions across the 4 age groups (Table 1).

Table (1): Comparison between the 4 different age groups regarding the measured dimensions regardless sex

(mm/ º)	20-29 years		30-39 years		40-49 years		50-60 years		p value
	Mean	±SD	Mean	±SD	Mean	±SD	Mean	±SD	
MRL	57.87	5.20	58.52	5.54	56.89	5.44	58.04	3.92	.432
MRB	35.72	3.16	37.01	2.95	36.62	2.94	36.49	2.49	.151
GA	120.72	6.05	121.14	6.08	119.96	5.10	119.45	5.79	.468
BGW	174.56	11.94	175.95	8.67	174.29	10.46	172.30	9.71	.368
AGA	163.72	7.59	163.65	9.40	165.17	8.72	160.61	11.80	.119
AGD	1.99	.99	1.91	1.13	1.57	.81	1.98	1.28	.168

ANOVA test **MRL**: Maximum Ramus Length, **MRB**: Maximum Ramus Breadth, **GA**: Gonial Angle, **BGW**: Bigonial width, **AGA**: Antegonial Angle, **AGD**: Antegonial Depth.

While, the comparison between the measured dimensions in males and females revealed a statistically difference in the mean of all measured dimensions between males and females in the studied sample, with higher mean values of linear measurements (maximum ramus length, maximum ramus breadth, bigonial width, and antegonial depth) in males than in females, however females had significantly greater mean values of angular measurements (gonial angle and antegonial angle) than males (p<0.001* for all) **(**Table 2).

Table (2): Comparison between males and females regarding the measured dimensions in the studied sample

Measured dimensions (mm/ º)	Sex								
	Female				Male				
	Mean	± SD	Minimum	Maximum	Mean	±SD	Minimum	Maximum	P value
MRL	54.43	3.33	47.60	63.70	61.45	4.03	53.90	74.10	<0.001*
MRB	35.32	2.66	28.10	41.90	37.68	2.70	32.20	44.80	<0.001*
GA	122.94	4.81	110.39	134.49	117.58	5.42	105.41	129.39	<0.001*
BGW	170.80	9.20	139.60	186.90	178.07	10.06	154.80	200.60	<0.001*
AGA	167.51	6.88	151.00	177.55	158.90	9.95	136.77	176.22	<0.001*
AGD	1.37	.73	.20	3.80	2.39	1.12	.20	5.50	<0.001*

Unpaired t-test, * P is significant

A comparison of the measured dimensions among the 4 different age groups of females revealed the results of post hoc analysis and analysis of variance (ANOVA). There was a statistically difference only in the **MRB** between group 1 and group 4 (p<0.02*). In males, comparing the 4 different age groups regarding the measured dimensions via ANOVA and post hoc tests, there was a statistically significant difference in **BGW** between group 4 and group 1 (p < 0.046*) and **AGA** between group 4 and both of group 2 and group 3 (p< 0.01* for both) (Table 3).

Table (3): Comparison between the 4 different age groups in females and males regarding the measured dimensions

(mm/ º)	females 20-29		females 30-39		females 40-49		females 50-60		p value	Post-hoc
	Mean	±SD	Mean	±SD	Mean	±SD	Mean	±SD		
MRL	54.30	3.23	54.31	3.31	53.49	3.15	55.77	3.46	.107	
MRB	34.11	3.17	35.58	2.39	35.35	2.12	36.36	2.46	.021*	4#1
GA	123.77	5.09	123.48	5.59	122.25	3.66	122.21	4.84	.534	
BGW	169.23	10.96	172.92	6.92	169.71	9.02	171.57	9.38	.452	
AGA	166.90	6.25	167.10	6.62	168.18	7.50	167.88	7.41	.894	
AGD	1.52	.77	1.44	.70	1.26	.71	1.24	.75	.446	
	males 20-29		**males 30-39**		**males 40-49**		**males 50-60**		**P value**	**Post-hoc**
	Mean	**± SD**	**Mean**	**± SD**	**Mean**	**± SD**	**Mean**	**± SD**		
MRL	61.89	3.89	62.41	4.16	60.87	4.86	60.42	2.83	.283	
MRB	37.53	1.99	38.32	2.84	38.12	3.11	36.63	2.56	.126	
GA	117.29	5.21	118.97	5.78	117.27	5.30	116.57	5.35	.442	
BGW	180.55	10.17	178.76	9.29	179.67	9.56	173.05	10.20	.046*	4#1
AGA	160.15	7.46	160.45	10.53	161.65	8.86	153.03	10.77	.011*	4#2,3
AGD	2.52	.95	2.35	1.28	1.94	.78	2.76	1.27	.084	

We randomly selected 40 participants (20 females and 20 males) to compare the right and left ramus measurements via paired t tests. The **MRL** and **MRB** significantly differed between the left and right rami (p<0.01* and p<0.001* respectively) **(Table 4)**.

Table (4): Comparison between the right ramus and left ramus measurements in a randomly selected 40 cases

		Paired Differences					t	Df	P value
		Mean	±Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	MRL right - MRL left	-.85750-	2.03330	.32149	-1.50778-	-.20722-	-2.667-	39	.011*
Pair 2	MRB right - MRB left	-1.02750-	1.86836	.29541	-1.62503-	-.42997-	-3.478-	39	.001*
Pair 3	GA right - GA left	.75750	3.12964	.49484	-.24341-	1.75841	1.531	39	.134
Pair 4	AGA right - AGA left	-.09925-	6.19641	.97974	-2.08096-	1.88246	-.101-	39	.920
Pair 5	AGD right - AGD left	-.02250-	.55815	.08825	-.20101-	.15601	-.255-	39	.800

Paired t- test * P is significant

Similar results were reported when comparing the right ramus and left ramus measurements in the 20 randomly selected female participants, as statistically significant differences in **MRL** and **MRB** were found between the right and left rami ($p<0.002$* and $p<0.019$* respectively). In 20 randomly selected male participants, the comparison revealed a statistically difference between the right and left rami in **MRB** only ($p<0.032$*) (Table 5).

Table (5): Comparison between the right ramus and left ramus measurements in a randomly selected 20 female cases and 20 male cases

		Female cases Paired Differences					T	df	P value
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	MRL right - MRL left	-1.06500-	1.29910	.29049	-1.67300-	-.45700-	-3.666-	19	.002*
Pair 2	MRB right - MRB left	-1.20000-	2.08806	.46690	-2.17724-	-.22276-	-2.570-	19	.019*
Pair 3	GA right - GA left	1.32900	3.07627	.68788	-.11074-	2.76874	1.932	19	.068
Pair 4	AGA right - AGA left	-.91850-	5.52211	1.23478	-3.50293-	1.66593	-.744-	19	.466
Pair 5	AGD right - AGD left	-.04500-	.60391	.13504	-.32764-	.23764	-.333-	19	.743
		Male case Paired Differences					**T**	**Df**	**P value**
		Mean	**Std. Deviation**	**Std. Error Mean**	**95% Confidence Interval of the Difference**				
					Lower	**Upper**			
Pair 1	MRL right - MRL left	-.65000-	2.58996	.57913	-1.86214-	.56214	-1.122-	19	.276
Pair 2	MRB right - MRB left	-.85500-	1.65608	.37031	-1.63007-	-.07993-	-2.309-	19	.032*
Pair 3	GA right - GA left	.18600	3.15496	.70547	-1.29057-	1.66257	.264	19	.795
Pair 4	AGA right - AGA left	.72000	6.84873	1.53142	-2.48530-	3.92530	.470	19	.644
Pair 5	AGD right - AGD left	.00000	.52315	.11698	-.24484-	.24484	.000	19	1.000

Paired t- test * P is significant

The correlation between different measurements and age within the whole studied sample revealed no significant correlation between any of the measured dimensions and age. Additionally, there was no statistical correlation between any of the measured dimensions and age within the different age groups; in group 1, group 2, and group 3 respectively, except for group, there was a statistically significant correlation between the **MRL**, **GA**, and **AGA** and age. This correlation was positive for MRL (r=0.560, p<0.001*) and negative for **GA** and **AGA** (r=-0.502, p<0.001*) and (r=-0.330, p<0.024*) respectively.

In females, there was a statistical positive correlation between **MRB** and age (r=0.287, p<0.003*). In males, there was a statistically significant negative correlation between **BGW** (r= -.238) and **AGA** (r= -.211) and age [(p<0.019*) and (p<0.038*), respectively]. To predict sex, discriminant function analysis was used. For every mandibular measurement examined, statistically significant disparities between males and females were discovered. However, after applying stepwise discriminant function analysis, it was found that maximum ramus length, antegonial angle, and antegonial depth were the only significant predictors for sex. Individuals of unknown sex can be categorized by calculating the **discriminant score**; this depends on the multiplication of each variable with its corresponding coefficient, summing them, and adding the resultant value to the constant (Table 6**)** as follows:

Discriminant score = a + [b1*(MRL) + b2*(AGA) + b3*(AGD)].where a= constant and b= coefficient of the measured dimension.

Table (6): Canonical discriminant function analysis for sex identification (dimensions' coefficients).

Measured dimensions (mm)	Coefficients (b)	Constant (a)
MRL	0.234 = (b1)	-8.858
AGA	-0.032 = (b2)	
AGD	0.313 = (b3)	

D= -8.858+ 0.234**MRL**-0.032**AGA**+ .313**AGD** Where D is the discriminant score, -8.858 is a constant.

The negative scores were categorized as females, and the positive scores were categorized by calculating males. The discriminant functions at the group centroids (group means) were -1.084 for females and 1.151 for males. According to the discriminant function analysis to identify sex via measured dimensions and the calculation of the discriminant score, 90.3% of the females and 83.5% of the males were correctly classified, so the overall correct classification was 87%. **Logistic regression analysis (LRA)** was used to predict sex, and the logistic regression model and variables in the equation were shown in **(Table 7).**

A logistic regression equation was constructed, and the obtained equation was as follows:

Sex= -34.796 + 0.566 **MRL +** 1.196**AGD,** where -34.796 is a constant.

Table (7): Logistic regression model to detect sex variables in the equation

		B	S.E.	Wald	Df	P value	OR	95% C.I. Lower	95% C.I. Upper
Sex	MRL	.566	.087	42.397	1	<0.001*	1.761	1.485	2.088
	AGD	1.196	.275	18.902	1	<0.001*	3.307	1.929	5.670
	Constant	-34.796	5.155	45.562	1	<0.001*	.000		

Both the **MRL** and **AGD** were significant predictors (p<0.001* for both). The percentage of correct sex predictions was calculated. A total of 86.4% of females were correctly categorized, and 83.5% of males were correctly categorized, with an overall accuracy of **85%** (Table 8).

Table (8): Percentage of correct sex prediction.

Sex	Positive results		Negative results		Total
	Count	Percentage	Count	Percentage	
female	89	86.4	14	13.6	103
Male	81	83.5	16	16.5	97
Overall Percentage	85.0				

DISCUSSION

Forensic examination is the process of determining age and sex from living or dead remains. The mandible is a crucial tool for radiological identification since it has several growth parameters and is frequently retrieved intact [11].

In the present work, a comparison was performed between the 4 age groups concerning the studied dimensions. Although there was a difference between the age groups under study, it was not statistically significant. This is in agreement with studies by **Ostovar Rad *et al.*** [12]. However, **Behl *et al.*** [6] and **Shah *et al.*** [13] significantly decreased in the gonial angle with increasing age. These differences may be explained by variations in sample size, ethnic group, and age groups.

In the current study, the comparison between the measured dimensions in males and females revealed a statistically difference in the mean values of all measured dimensions, with higher mean values of linear measurements in males than in females. However, females had significantly higher mean values of angular measurements than males did. 0.001* for all). These results partially agree with the results of a previous study by **Mostafa & Abou El-Fotouh** [14]**,** who concluded that males had a greater mean than females did for every measurement except the gonial angle, ramus notch depth, and horizontal length. Additionally, **Kurniawan *et al.***[15] reported similar results. However, I**ngaleshwar *et al.*** [5] concluded that all measurements were greater in males.

Males and females may have different mandibular sizes due to variations in bone remodeling tendencies. Bone remodeling and formation patterns can be influenced by genetics, race, masticatory muscle activity, hormones, and socioenvironmental variables, including diet, cuisine, climate, and diseases. Males often have greater bone volume and size than females do because of bone formation in the periosteum vs. the endosteum [16-18].

A comparison of females in the 4 different age groups revealed that there was a significant difference only in maximum ramus breadth (MRB) between group 1 and group 4 (p<0.02*). In males, a comparison of the 4 different age groups revealed that there was a statistically significant difference in the bigonial width (BGW) between group 4 and group 1 (p<0.046*) and in the antegonial angle between group 4 and both group 2 and group 3 (p<0.01* for both). These results partially agree with the results of a previous study by **Muskaan & Sarkar** [19] who reported that there was no discernible difference between different genders in groups I (ages 21–30) and II (ages 31–40) in terms of the maximal width of the mandibular ramus on the right and left sides. Additionally, a considerable difference is observed between the male and female members of groups III (41–50 years) and IV (51–60 years).

We randomly selected 40 cases (20 females and 20 males) to compare the right and left ramus measurements, there was a significant difference between the right and left rami in maximum ramus length (MRL) and maximum ramus breadth (MRB) (p<0.01* and p<0.001*, respectively). These findings agree with those of studies performed by **Elsayed *et al.***[20] and **Sairam *et al.***[21] who found a significant increase in the means of left and right MRL in males compared to females. In contrast to this work, **Tejavathi Nagaraj *et al.***[22] reported no significant differences between males and females in the Indian population.

For the bilateral comparison measurements, the mandibular dimensions were measured bilaterally in a randomly selected sample that included 20 males and 20 females. The results revealed a statistically significant difference between the right and left rami in maximum ramus length (MRL) and maximum ramus breadth (MRB) (p<0.01* and p<0.001* respectively) in females for MRB (p<0.019*) and for MRL (p<0.002*) and in males for MRB (p<0.032*). The same findings were previously reported by **Chole *et al.*** [10]. On the other hand, **Taleb & Beshlawy** [23] showed no significant difference between the right and left sides regarding the linear and angular measurements.

The correlation between different measurements and age within the whole studied sample revealed no significant correlation between all the measured dimensions and age and age within the different age groups except for **group 4 (50–60 yrs.)** and there was a statistical correlation between the MRL, GA and AGA and age. This correlation was positive for MRL (r=0.560, p<0.001*) and negative for GA and AGA (r=-0.502, p<0.001*) and (r=-0.330, p<0.024*) respectively. These findings were partially consistent with those of a previous study [24]**.** This is clearly explained by the fact that the mandibular ramus will be closer to the mandibular mental as the gonial angle decreases with age, resulting in a lower maximum mandible length. In females, there was a positive correlation between maximum ramus breadth (MRB) and age (r=0.287) (p<0.003*). Our findings were slightly similar to those of **Ghaffari *et al.*** [25]. Using computed tomography (CT) scans from 124 participants (70 men and 54 women, ages 21--50), they reported that the maximal ramus breadth decreased with age in both sexes. In contrast, **Taleb & Beshlawy** [23] revealed a positive (direct) and significant relationship between age and the linear measures of the mandibular ramus in both males and females. This distinction may be clarified by the fact that the age ranged of their sample was wider than that of our sample. In males, there was a negative correlation between bigonial width (BGW) (r= -.238) and antegonial angle (r= -.211) and age [(p<0.019*) and (p<0.038*], respectively]. This runs counter to certain studies that reported that the gonial angle increased with age [25, 26]. Another study reported that the gonial angle decreases with age [27], which is similar to our findings. The varying age ranges and dental statuses used for those studies may be the reason for the disparate findings of the link between gonial angle and age that were reported in different studies.

In the present study, for every mandibular measurement under study, statistically significant disparities between males and females were discovered, however after applying stepwise discriminant function analysis, the maximum ramus length, antegonial angle and antegonial depth were the only significant predictors for sex, with a discriminant score of 90.3% of the females and 83.5% of the males with an overall correct classification of 87%. Using the most dimorphic mandibular features, a formula was created in this research to accurately predict the sex of the mandible. Positive scores were categorized as male, whereas negative scores were categorized as female. For males and females, the discriminate functions at group centroids were 1.151 and -1.084 respectively. Although this formula has many limitations, such as a small sample size and the presence of confounders such as malnutrition that could alter the results, it could be applied to the Egyptian population.

Both the MRL and AGD were significant predictors ($p<0.001$* for both). The percentage of correct sex predictions was calculated. A total of 86.4% of females were correctly categorized, and 83.5% of males with an overall accuracy of 85%. In an Egyptian study, **Kharoshah *et al.*** [28] examined 330 Egyptian patients to determine the accuracy of six mandibular metric factors in determining sex via spiral CT. Only three parameters, minimum ramus breadth, bicondylar breadth, and gonial angle were shown to be considerably greater in men than in females. Additionally, with an overall prediction accuracy of 83.9%, the optimal model identified by stepwise discriminate analysis employed four parameters: Minimum ramus breadth, ramus length, gonion angle, and bicondylar breadth. **Indira *et al.*** [29] revealed that minimum ramus breadth, condylar height, and projective height were the most effective standards used for sex discrimination, with an prediction accuracy percentage of 76%.

LIMITATIONS AND RECOMMENDATIONS

This study had some limitations as the relatively small sample size that may reduce the generalizability of the results. Additionally, the study was limited to Egyptian population, which may limit the data applicability to other ethnic groups. Future research including a larger and more diverse sample size is recommended with expanding the study population beyond the Egyptian demographic to allow for comparative analysis across different ethnic groups.

CONCLUSION

The current findings suggested that certain mandibular measurements may have potential utility in sex estimation for forensic identification, with males generally showing higher values in linear dimensions (MRL, MRB, BGW, AGD), and females showing higher angular measurements (GA, AGA). Among the variables assessed, MRL, AGA and AGD appeared to contribute most to sex differentiation in this sample through achieving high classification accuracy.

List of abbreviations:

- **AGA:** Antegonial Angle
- **AGD:** Antegonial Depth
- **ANOVA:** Analysis of variance.
- **BGW:** Bigonial width
- **Cs:** Superior condyles
- **CT:** Computed Tomography
- **DICOM:** Digital Imaging and Communications in Medicine
- **GA:** Gonial Angle
- **GO:** Gonion
- **LRA:** logistic regression analysis
- **MRB:** Maximum ramus breadth
- **MRL:** Maximum ramus length
- **OPG:** Orthopantomagram
- **SPSS:** Statistical Package of Social Sciences**.**

DECLARATIONS

- **Consent to participate:** The participants informed that their participation was voluntary, and consent was obtained before the study was conducted.

- **Conflict of interest:** Not applicable.
- **Funding:** Not applicable.

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