Evaluation of the Usefulness of Some Mandibular Measurements for Sex and Age Prediction in a Sample of Egyptian Population

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KEYWORDS
Identification,
Orthopantomographs,
Maximum ramus breadth,
Minimum ramus breadth,
Coronoid height,
Mental index.

ABSTRACT

The mandible is the largest and strongest bone of the face which can play a role in sex and age identification. The aim of the present study was to evaluate the usefulness of some mandibular measurements in digital dental panoramic radiographs for identification of sex and age in a sample of Egyptian population. Digital panoramic radiographs from 150 Egyptian participants of known age and sex were included. They were used to measure the maximum ramus breadth, minimum ramus breadth, coronoid height and mental index. The four studied measurements' values were higher in males than in females. Among the four measurements, only maximum ramus breadth was found to contribute significantly for sex prediction. A logistic regression equation for prediction of sex was derived. The four studied measurements showed a strong positive, statistically significant correlation with age in both sexes. Multiple regression analysis was conducted to predict age based on the four measurements. However, the contributions of minimal ramus breadth and coronoid height to the model were not statistically significant. Therefore, only the maximum ramus breadth, mental index in addition to sex were included in the regression model to obtain an equation for age prediction. It was concluded that the mandible exhibits sexual dimorphism and can be used to predict sex with quite satisfactory results based on measuring the maximum ramus breadth according to the derived equation. Furthermore, the four studied parameters showed a strong positive correlation with age and two of them (the maximum ramus breadth and the mental index) contributed significantly to the age prediction equation.

Introduction

Identification is a very important and necessary step in medicolegal practice; either it is identification of a living or deceased individuals. Identification of skeletal remains is one of the most hard tasks in forensic pathology because in many cases the skeleton is recovered incomplete (İlgüy et al., 2014).

Estimation of sex is one of the first stages of identification. Age estimation is also one of the important duties of medicolegal practitioners (Indira et al., 2012; Jangam et al., 2014). Skeleton has always aided in sex and age determination of living and non- living individuals (Dayal et al., 2008).

The mandible is the largest and strongest bone of the face. The presence of a dense layer of compact bone makes it very robust (Akhlaghi et al., 2014). The mandible is a sexually dimorphic bone. The relative development of the masticatory muscles influences the expression of mandibular

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dimorphism (Indira et al., 2012). In addition, many authors have described number of changes that take place in the morphology of the human mandible with advancing age (Chole et al., 2013) .

Panoramic X-ray is widely accessible and is used in daily clinical routine to assess the vital structures of the mandible. Their principal advantages are wide coverage, low dose of radiation, and the short time required for obtaining images (Al-Shamout et al., 2012). The mandible is considered as an essential tool for identification in radiology because of numerous growth parameters that can be detected, no overlying bony structures and easy imaging (Dhaka et al., 2015).

The aim of the present study was to evaluate the usefulness of some mandibular measurements (the maximum and the minimum ramus breadth, the coronoid height and the mental index) in digital dental panoramic radiographs for identification of sex and age in a sample of Egyptian population

Subjects and Methods

This study was conducted on 150 digital panoramic radiographs taken at the Oral Medicine, Periodontology, Oral Diagnosis and Radiology Department, Faculty of Dentistry, Tanta University from 150 Egyptian participants of known sex and age. Written informed consent for participation was taken from the participants or their guardians. Approval for the study was obtained from the ethical committee of Faculty of Medicine, Tanta University.

The digital panoramic radiographs were carefully selected. Only radiographs with good to perfect quality were included. The radiographic measurements were done, under supervision of an expert dentist, with the SIDEXIS-XG 2.52 software (by Sirona© dental system GmbH) for accuracy and precision. This software allows linear as well as curvilinear measurements between any two points or multiple points.

Exclusion criteria

1. Participants with any anomalies including; missing teeth, cleft lip, cleft palate, congenital anomalies, and cranio-facial pathology.
2. Pregnant females.

The following measurements were done (Figures 1-3):

1. <u>*Maximum ramus breadth:*</u> the distance between the most anterior point on the mandibular ramus to the most posterior point on the mandibular ramus
2. <u>*Minimum ramus breadth:*</u> the smallest anterior posterior diameter of the ramus.
3. <u>*Coronoid height:*</u> the projective distance between coronion and angle of the mandible.
4. <u>*Mental index:*</u> the cortical width of the mandible below the mental foremen. It was assessed by identifying the mental foramen and then tracing a line, which passes perpendicular to the tangent, to the lower border of the mandible and through the inferior border of mental foramen.

All these measurements were done according to Muskaan et al. (2015). All measurements were done on the right side of the mandible as the difference between the values of measurements of the right and left sides is statistically insignificant (Sambhana et al., 2016).

Statistical analysis:

The collected data were organized and statistically analyzed using SPSS software statistical computer package for windows version 22. For quantitative data, the Shapiro-Wilk test for normality was performed. For normally distributed data, values were expressed as mean ± standard deviation and Independent samples T test was performed for comparison between two groups. For data that were not normally distributed median and interquartile range (expressed as 25th-75th percentiles) were calculated and Mann-Whitney test, Kruskal Wallis test and Spearman's rank-order correlation were used. For qualitative data, Pearson's Chi square test was used to examine association between two variables. Significance was adopted at $p < 0.05$ for interpretation of results of tests (Dawson-Saunders and Trapp, 2001).

Results:

The current study included ortho-pantomographs from 150 participants of known sex (78 female and 72 male) and age. Their age ranged between 4 and 50 years with a median of 23 years. The median age for females was 22 years, while that of males was 24 years (Table 1). Additionally, table (1) shows the distribution of male and female participants in each age group. It was observed that there was no statistically significant difference between both sexes as regards the age.

Fig.(1): The measurements of maximum and minimum ramus breadth on panoramic radiograph.

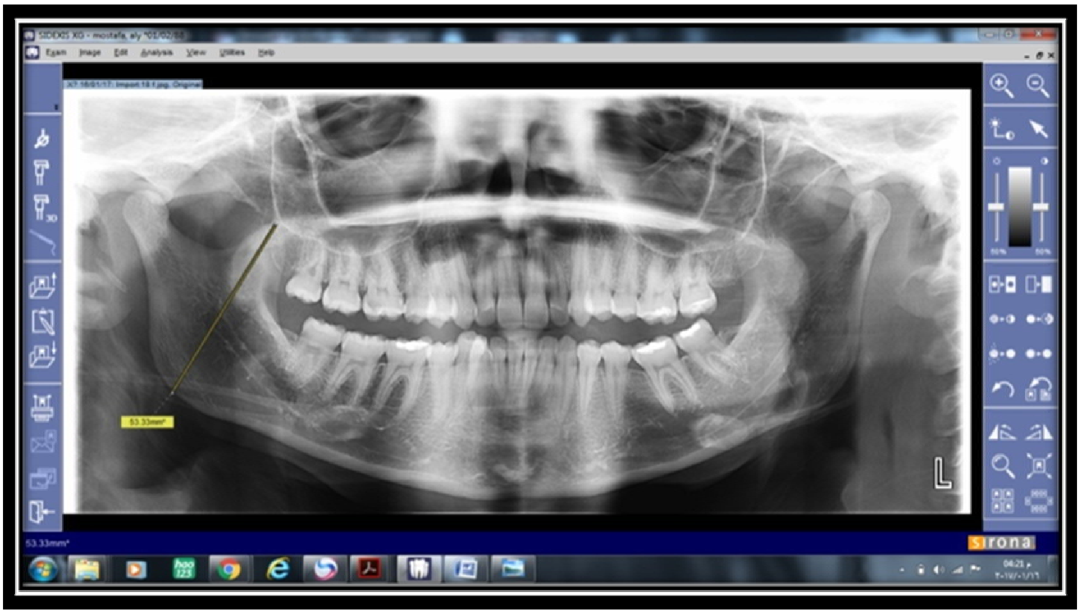

Fig. (2): The measurement of coronoid height on panoramic radiographs.

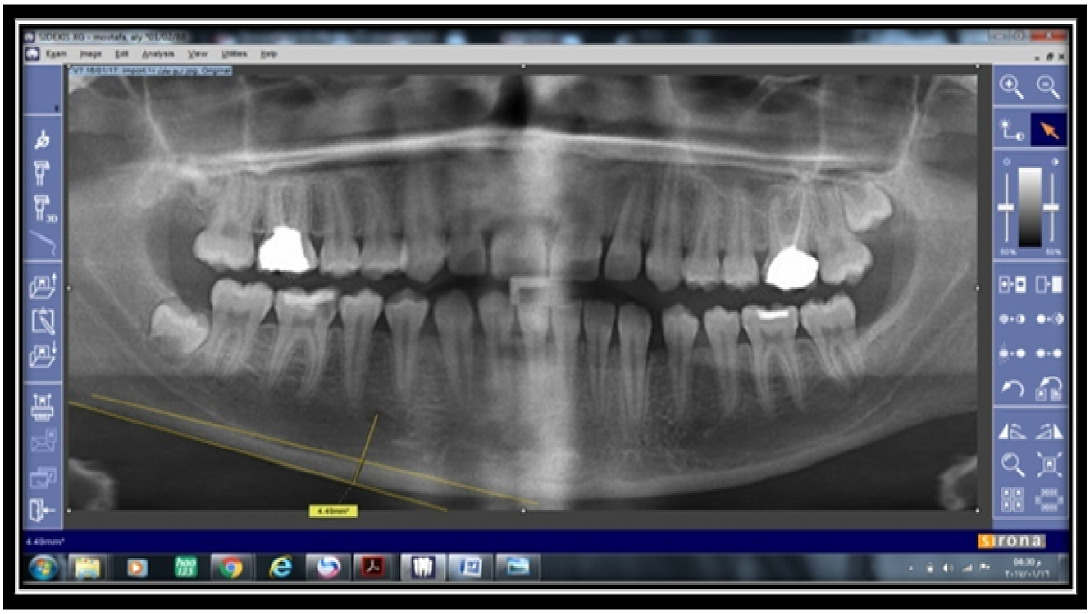

Fig. (3): The measurement of mental index on panoramic radiographs.

Table (1): Age and sex of the studied participants.

		Sex			Tests of significance	
		Female	**Male**	**Total**	**Test statistic**	**p**
Age (years)	Min-Max	6.0-50.0	4.0-50.0	4.0-50.0	Z_{MW}=0.474	0.635
	Median	22.5	24.0	23.0		
	IQR	13.0-37.0	11.0-34.5	12.0-36.0		
	Mean ranks	77.12	73.75			
Age groups	≤ 10	12 (15.4%)	17 (23.6%)	29 (19.3%)	X_{ChS}=2.537	0.638
	>10-20	21 (26.9%)	14 (19.4%)	35 (23.3%)		
	>20-30	19 (24.4%)	17 (23.6%)	36 (24.0%)		
	>30-40	14 (17.9%)	11 (15.3%)	25 (16.7%)		
	>40-50	12 (15.4%)	13 (18.1%)	25 (16.7%)		
	Total	78 (100%)	72 (100%)	150 (100%)		

n= number, Min-Max: Minimum-Maximum, IQR: interquartile range, X_{ChS}: Pearson's Chi square test, Z_{MW}: Mann-Whitney test.

The four studied measurements' values were higher in males than in females. The difference between both sexes in the measurements' values wasn't statistically significant except for the value of the maximum ramus breadth (Table 2).

Table(2): Comparison between female and male subjects as regards the four studied measurements.

		Studied participants		Test of significance	
		Female (n=78)	**Male (n = 72)**	**Test statistic**	**p**
Maximum ramus breadth (mm)	Minimum	21.7	21.3	Z_{MW}= 2.184	0.029*
	Maximum	42.4	44.9		
	Median	32.1	34.5		
	IQR	28.3 - 36.3	30.0 - 39.3		
	Mean ranks	68.1	83.6		
Minimum ramus breadth (mm)	Minimum	20.4	19.4	Z_{MW}= 1.924	0.054
	Maximum	40.6	41.2		
	Median	28.9	31.7		
	IQR	25.7 - 33.9	26.9 - 36.3		
	Mean ranks	68.9	82.6		
Coronoid height (mm)	Minimum	28.8	29.6	Z_{MW}= 0.404	0.686
	Maximum	64.9	81.2		
	Median	53.5	53.2		
	IQR	49.7 - 55.9	48.7 - 57.0		
	Mean ranks	74.1	77.0		
Mental index (mm)	Minimum	1.9	1.7	t= -1.706	0.090
	Maximum	6.2	8.9		
	Mean	4.1	4.5		
	Standard Deviation	1.1	1.6		

n= number; IQR: interquartile range; Z_{MW}: Mann Whitney test; t: Independent samples T test, * Significant.

For sex prediction from the four studied measurements, a stepwise forward binary logistic regression analysis was performed. Among the four measurements, only maximum ramus breadth was found to contribute significantly to the model. The logistic regression model was statistically significant (χ^2 = 5.894, p = 0.015). The model explained 5.1% (Nagelkerke R^2) of the variance in sex and correctly classified 57.3% of cases. Sensitivity was 50% (was able to correctly identify 50% of male participants as males), and specificity was 64.1% (was able to correctly identify 64.1% of female participants as females) (Table 3).

Table (3): Binary logistic regression predicting sex based on maximum ramus breadth.

Chi square test		Nagelkerke R Square	Percentage accuracy in classification	Variables	Coefficients			Exp(B) (Odds ratio)	95% CI for odds ratio
X^2	P				B	SE	Sig.		
5.894	0.015*	0.051	57.3%	Maximum ramus breadth	0.072	0.30	0.017*	1.075	1.013 - 1.141
				Constant	-2.511	1.036	0.015*	0.081	

SE =standard error of unstandardized coefficients; *significant, CI: confidence interval

A logistic regression equation for prediction of sex was derived as follows:

Logit (p) = -2.511 + (0.072 × maximum ramus breadth)

Where (p) is the probability of being male. Logit (p) can be transformed to (p) by the following formula:

$$wp = \frac{1}{1+e^{-\mathrm{logit}\,(p)}}$$

Results of Spearman's rank-order correlation between age and the four studied measurements showed a strong positive, statistically significant correlation in both females and males. All correlation coefficients were > 0.5 with p <0.001 (Tables 4 and 5).

Table (4): Correlation between age and the four studied measurements in females.

		Age (years)
Maximum ramus breadth	r_s	0.754
	P	<0.001*
Minimum ramus breadth	r_s	0.755
	P	<0.001*
Coronoid height	r_s	0.553
	P	0.001*
Mental index	r_s	0.743
	P	<0.001*

r_s: Spearmann's rank order correlation, *significant.

Table (5): Correlation between age and the four studied measurements in males.

		Age (years)
Maximum ramus breadth	r_s	0.790
	P	<0.001*
Minimum ramus breadth	r_s	0.775
	P	<0.001*
Coronoid height	r_s	0.601
	P	<0.001*
Mental index	r_s	0.833
	P	<0.001*

r_s: Spearmann's rank order correlation, *Significant.

Multiple regression analysis was conducted to predict age based on the four studied measurements in addition to the sex. However, the contributions of minimal ramus breadth and coronoid height to the model were not statistically significant. Therefore, maximum ramus breadth, mental index in addition to sex were included in the model. The model was statistically significant to predict age (F = 105.278, p < 0.001, adjusted R^2 = 0.677). These three variables added statistically significantly to the prediction, p < 0.001 (Table 6).

Table (6): Multiple regression for prediction of age based on maximum ramus breadth, mental index and sex.

ANOVA test		Adjusted R square	Variable	Unstandardized Coefficients			T test	
F	p			B	SE	95% Confidence interval	t	p
105.278	<0.001*	0.677	Constant	-30.88	3.88	-38.54 to -23.21	-7.964	<0.001*
			Maximum ramus breadth	1.18	0.16	0.87 to 1.48	7.580	<0.001*
			Mental index	4.23	0.64	2.97 to 5.49	6.642	<0.001*
			Sex	-4.88	1.27	-7.39 to -2.36	-3.831	<0.001*

SE =standard error of unstandardized coefficients, *Significant.

An equation to predict age was obtained from the regression model as follows:
Predicted age (years) = -30.88+ (1.18 × maximum ramus breadth) + (4.23 × mental index) - (4.88 × sex).

Where sex was coded as 0 for female and 1 for male

Discussion

Sex identification is of great importance as it excludes half the population. Since complete skeletons are difficult to be restored, sexual dimorphism should be studied in different bones to assess their accountability to identify sex of the examined subject (Bigoni et al., 2010). Age estimation is gaining more value in recent years because of wars & immigration. The use of non-invasive methods for identification is generally preferred and is a must in case of living individuals (Brkić et al., 2000; Lynch, 2003).

The mandible was chosen in the current study because it is the hardest bone in the face which keeps its shape better than any other bone in forensic anthropology fields. Mandible shows sex differences since early stages of life. In addition, many authors have described number of changes that take place in the morphology of the human mandible with advancing age (Chole et al., 2013).

All values of the four measurements included in the present study were higher in males than females. This difference was non-significant except for the maximum ramus breadth. This was partially consistent with Saini et al. (2011) and Indira et al. (2012) who conducted their studies in India. Saini et al. study was done on 116 dry adult mandibles, 92 males and 24 females, while Indira et al., study was done on 100 orthopantomographs, 50 male and 50 female. Both studies took five measurements including maximum ramus breadth, minimum ramus breadth, coronoid height, condylar height and projective height of ramus. They found that the mean values of all these measurements were significantly higher in males than in females. Furthermore, the result of the present study is partially different from results obtained by Damera et al. (2016) from India who conducted their study on 80 orthopantomographs of Visakhapatnam's population. They studied seven measurements including maximum ramus breadth, minimum ramus breadth, maximum ramus height, projective height of ramus, coronoid height, bigonial angle and bigonial width. They found that the mean values of the maximum ramus height, projective height of ramus, coronoid height and bigonial angle were significantly higher in males than females, while the mean values of the maximum ramus breadth and bigonial width were non-significantly higher in males than females. As regards the minimum ramus breadth, it was non-significantly higher in females than males.

The higher male values may be explained by the fact that, generally, the masticatory force is greater in men than in women. The elevating muscles' contraction during mastication exerts pressure throughout the mandibular ramus and so increases its measurements. Furthermore, in the adult phase, the speed and rate of growth are higher in men, so craniofacial dimensions in males are bigger when compared with those of females (Akgül and Toygar, 2002; Agthong et al., 2005).

Stepwise forward binary logistic regression analysis was performed for prediction of sex and it was found that the maximum ramus breadth was the only parameter that contributed significantly to the model but even this prediction was quite low (50% sensitivity, and 64.1% specificity).

Abu-Taleb and El Beshlawy (2015) have done a study on 191 panoramic images (105 males and 86 females) of Egyptian patients aged from 6 to 70 years old. They studied five mandibular ramus linear measurements (upper ramus breadth, lower ramus breadth, projective height, condylar ramus height and coronoid ramus height) and gonial angle measurements. They tried to predict sex and they found significant differences between males and females as regards the mean of all these measurements; however, the condylar ramus height was the only significant sex predictor with overall correct classification of 79.6%. In addition, Kharoshah et al. (2010) have done a study on 330 three-dimensional spiral computed tomographic images (165 males and 165 females) of Egyptian subjects aged from 6 to 60 years. Their measurements included: gonial angle, ramus length, minimum ramus breadth, mandibular base length, bigonial breadth and bicondylar breadth. They conducted a stepwise discriminant analysis and recognized four mandibular measurements as final predictors of sex. These measurements are: the bicondylar breadth, gonial angle, minimum ramus breadth and ramus length with an overall predictive accuracy of 83.9%. Despite that these studies were done on Egyptians, the differences in the sample size, included ages, combination of measurements, used techniques and finally the different used statistical analysis method could all explain the discrepancy in results between the current study and their studies.

The present study revealed a strong positive, statistically significant correlation between age and the four studied measurements in both males and females. This was in accordance with Abu-Taleb and El Beshlawy (2015) who found a statistically significant positive correlation between age and their studied ramus linear measurements. Meanwhile, the mental index positive correlation with age observed in this study wasn't in agreement with Muskaan and Sarkar (2015) who concluded a general decrease in mental index with increasing age.

Multiple regression analysis was conducted to predict age based on the four studied parameters in addition to sex. It showed that the contribution of minimum ramus breadth and coronoid height to the model were not statistically significant. Therefore, only the maximum ramus breadth, mental index in addition to sex were included in the model. This result disagreed with Abu-Taleb and El Beshlawy (2015) who reported that the coronoid ramus height was the only statistically significant predictor of age in both sexes and in the whole study sample. Again, this discrepancy between their results and ours might be due to their larger study sample size and the different age range in both studies.

Conclusion

The present study concluded that the mandible exhibits sexual dimorphism in the selected sample of Egyptian population. It can be used to predict sex with quite satisfactory results based on measuring the maximum ramus breadth according to the derived equation. In addition, the four studied parameters showed a strong positive correlation with age and two of them (the maximum ramus breadth and the mental index) contributed significantly to the age prediction equation.

Recommendations

Further studies on a larger sample size, wider range of age, and form different governorates of Egypt are recommended. Furthermore, the maximum ramus breadth and the mental index are recommended to be used in age identification according to the equation derived from this study.

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تقييم فائدة بعض القياسات الفكية في التنبؤ بالجنس والعمر في عينة من الشعب المصري

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****قسم طب الفم وأمراض اللثة و طرق التشخيص و الأشعة- كلية طب الأسنان- جامعة طنطا**

الفك السفلي هو أكبر وأقوى عظام الوجه و التي يمكن أن تلعب دورا في الاستعراف على الجنس والعمر. و قد كان الهدف من هذه الدراسة هو تقييم فائدة بعض قياسات الفك السفلي في التصوير الاشعاعي البانورامي الرقمي في الاستعراف على الجنس والعمر في عينة من الشعب المصري. وقد تضمنت الدراسه صور الاشعات البانوراميـة الرقميـة مـن ١٥٠ مشاركا مصريا معروفـي الجنس و العمر. وقد استخدمت هذه الاشعات لقياس أقصي عرض لفرع الفك السفلي، أقل عرض لفرع الفك السفلي، ارتفاع الإكليل، سمك قشرة الفك السفلي في مستوي الفتحة الفكية. و قد كانت قيم القياسات الأربعة التي تمت دراستها أعلى في الذكور منها لدى الإناث. ومن بين القياسات الأربعة، تبين أن قياس أقصي عرض لفرع الفك السفلي هو الوحيد الذي اسهم بشكل ملحوظ في التنبؤ بالجنس. وقد تم استنباط معادلة الانحدار اللوجستي للتنبؤ بالجنس. كما أظهرت القياسات الأربعة التي تمت دراستها علاقة إيجابية قوية ذات دلالة إحصائية مع العمر في كلا الجنسين. و قد تم إجراء تحليل الانحدار المتعدد للتنبؤ بالعمر بناء على القياسات الأربعة. و لكن وجد ان مساهمة قياس أقل عرض لفرع الفك السفلي و قياس ارتفاع الإكليل في النموذج لم تكن ذات دلالة إحصائية. لذلك تم أدراج قياس أقصي عرض لفرع الفك السفلي و سمك قشرة الفك السفلي في مستوي الفتحة الفكية فقط بالإضافة إلى الجنس في نموذج الانحدار للحصول على معادلة التنبؤ بالعمر. وقد خلصت الدراسة إلى أن الفك السفلي يظهر ازدواجا في الشكل الجنسي ويمكن استخدامه للحصول على نتائج مرضية الى حد ما في التنبؤ بالجنس بناءا على قياس أقصي عرض لفرع الفك السفلي وفقا للمعادلة المشتقة. وعلاوة على ذلك، فقد أظهرت القياسات الأربعة التي تمت دراستها علاقة إيجابية قوية مع العمر و ساهم اثنين منهم (قياس أقصي عرض لفرع الفك السفلي و سمك قشرة الفك السفلي في مستوي الفتحة الفكية) بشكل كبير في معادلة التنبؤ بالعمر.