Original article

Determination of Gender from Sternal Measurements Using Computed Tomography Imaging in a Sample of Sohag Governorate Population.

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ABSTRACT

Personal identification of unknown human remains is one of the most important roles in any forensic investigation. Sex identification can be determined either from their anthropometry or **Objectives**: The present work was performed to investigate the probability of determination of sex from various sternal measurements through Multi- detector Computed Tomography imaging. **Methodology**: The present work included 100 adult participants attended Sohag University Hospitals during the period from January 2020 to December 2020, 50 were males, and 50 were females who performed chest Computed Tomography (C.T.). **Results**: A significant statistical increase in the mean values of all sternal measurements in males as compared to females except sternal index. The correct percentage of sex prediction was 88% in males and 92% in females and 90% of overall sex percent. For each measurement, determination of the cut-off value between sensitivity and specificity showed that sternal body length and combined length were the most specific and sensitive with accuracy 100% to discriminate between both genders. **Conclusion**: Multi- detector Computed Tomography imaging revealed that the sternal body length and combined length were the best discriminate variables between genders with overall accuracy of 100% both females and males.

Keywords: Sternal measurements, Computed tomography imaging, Sexual dimorphism.

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I. INTRODUCTION

Personal identification means assigning human remains to a specific identity based on individualizing characteristics that can be recognized both in ante-mortem and in post-mortem data. When personal identification is requested, several disciplines can be applied, such as odontology, genetics and dactyloscopy. However, when no dactyloscopic or genetic profiles can be retrieved, forensic radiology is one of the most successful manners of reaching a positive identification (***Angelis et al., 2020)***

Identification depends on the type and number of bones available. If the whole skeleton is present, identification of age and sex can be detected with 80% to 100% accuracy **(Tejavathi et al., 2017).**

Sex identification specifically remains is a crucial aspect of identifying unknown human remains in forensic medicine, mainly when it is impossible to obtain whole skeletons or remains for analysis ***(Kiran et al., 2014).***

Preserved bone fragments even a single piece could provide a rapid classification and identification of victims in mass disaster. Sternum which has a firm structure and its preserved integrity is the chief bony structural advantages **(Sidler et al., 2007).** There are many differences in the sternum between male and females which demonstrating sex with accuracy above 80% in several populations **(Macaluso, 2010; Spradley and Jantz, 2011).**

The sternum may remain intact for a long time even in severe bone destruction, as it is protected within the chest. Studies performed on the sternum may be more convenient than the other body bones **(Saraf et al., 2018).**

Using the newest technology of Multi-Slice Computed Tomography (MSCT) makes it possible to form images that are very similar to the original of the bone shape that needs to be measured, in any axis and in a rapid manner. Therefore the clinical diagnostic importance of radiological methods like Computed Tomography (CT) and Magnetic Resonance Imaging (MRI) which have high resolution and in which three dimensional (3D) images can be obtained can be used for morphometric studies. (***Franklin et al., 2014 and Chowdhuri et al., 2019).***

Aim of the work

The present work aims to evaluate various human sternal measurements in sex determination using three dimensional multidetector Computed Tomography imaging in a sample of Sohag governorate population.

II. SUBJECTS AND METHODS

1- Subjects:

The present work was conducted on 100 subjects (50 males and 50 females). Who were selected from the patients attended to the Radiology Department at Sohag University Hospitals, as they have any chest problem or trauma but their CT scans didn't show any pathological findings. Their ages ranged from 25 to 45 years. The age and sex of the participants were recorded.

Exclusion criteria: Subjects excluded from the study those with a history of trauma of the sternum, fracture or malunion of the sternum, congenital anomalies in the sternum, any sternal pathology and sternal surgical interference.

The study was approved by scientific ethical committees of Sohag Faculty of Medicine, and written informed consent was obtained from all subjects.

2-Apparatus:

All subjects were examined by Toshiba 16 (16 slice) Multi Detector Computed Tomography Scanner at Radiology Department in Sohag University Hospitals. The formatting and enhancement of images obtained from this high-quality apparatus provided perfect and reproducible measurements.

3-Methods

Sternal measurements were evaluated to determine the sex using (3 dimintional Multi-detector Computed Tomography imaging. Measurements carried out using Dicom viewer software which is a built in software with the apparatus by using Mouse-Driven method by moving the mouse and drawing lines using selected points on the C.T imaging.

Sternal measurements: (Franklin et al., 2012). As shown in (Figure 1)

- Manubrium width (MW): at the level of the line passing from the incisura costalis one midpoint on right and left.
- Manubrium length (M): the longest distance from midpoint of the manubrium and the manubriosternal junction.
- Sternal body length (B): the longest distance between manubriosternal and mesoxipoid junction.
- Combined length of manubrium and sternal body (CL): sum of manubrium length (M) and sternal body length (B).
- Sternal index (SI): It is the division of M by B, then multiplied by 100 [(M/B) x 100].
- Width of sternal body at 1st sternal depression (Csw1): Direct distance (anterior aspect) between left and right midpoints between facets for second and third costal cartilage.

- Width of sternal body at 3rd sternal depression (Csw3): Direct distance (anterior aspect) between left and right midpoints between facets for fourth and fifth costal cartilage.
- Width of sternum at suprasternal notch: direct distance between 2 edges of suprasternal notch **(Rajendra et al., 2017).**

Statistical analysis:-

The collected data were analyzed using the SPSS computer program version 20. Quantitative data were expressed as means ± standard deviation in tables. Qualitative data was expressed as number and percentage. The student's t-test was used for independent samples to compare values between males and females. When p. value ≤=0.01 is highly significant, ≤=0.05 is significant and >0.05 is not significant. The relation between sex and each of sternal measurement in the known studied persons was analyzed by multivariate logistic regression analysis. The expontial B (Odds ratio) was used to quantify the efficiency of each sternal measurement in sex determination in the studied sample. The discriminant function equations and cross-validated classification accuracies for sternal measurements of the studied sample were calculated. Receiver operating characteristic (ROC) curve was constructed for optimum cut off points of the studied measures in predicting gender. Optimal cut-off values were determined; sensitivity, specificity and accuracy were calculated.

III. RESULTS

In the present work, no significant statistical difference was found in the mean value of age between males and females as regard different sternal measures (P = 0.926). The mean value of age for males was (37.2± 6.2) and the mean value of age for females was (37.1±6.6) as shown in (Table 1).

A highly significant statistical difference in the mean values of the manubrium width and the manubrium length was detected between males and females where P-value (P<0.001 and p<0.001 respectively). The mean value of the manubrium width and length in males (66.4 and 47 respectively) was higher than that of females (54.3 and 42.3 respectively) as shown in (Table 2 and Figures 2&3).

Among male and female participants there was a highly significant statistical difference in the mean values of the sternal body length and the combined sternal length between males and females where (p<0.001 and p<0.001 respectively). The mean value of the sternal body length and the combined sternal length in males (98.3 and 145.3 respectively) was higher than that of females (76.9 and 119.3 respectively) as shown in (Table 3 and Figures 4&5).

As regard sternal index, (Table 3) showed a highly significant statistical difference in the mean values of the sternal index between males and females where ($p<0.001$). The mean value of the sternal index in males (47.8) was lower than that of females (55.1).

According to the width of sternal body at the 1st sternal depression (Csw1) and the width of sternal body at the 3rd sternal depression (Csw3) (Table 4 and Figures 4&5) showed a highly significant statistical difference in the mean values between males and females where ($p<0.001$). The mean value of (Csw1) and (Csw3) in males (26.4 and 33.6 respectively) was higher than that of females (23.3 and 26.9 respectively).

Among male and female participants a highly significant statistical difference was found in the mean values of the width of sternum at supra sternal notch between males and females where ($p<0.001$). The mean value of the width of sternum at supra sternal notch in males (25.002) was higher than that of females (23.2) as shown in (Table 4).

- The percentage of correct prediction of sex:-

The percentage of correct prediction of sex is calculated for both males and females using discriminant function equations and cross-validated classification accuracies. The correct percentage of sex prediction was 88% in males and 92% in females and 90% of overall sex percent as presented in (Table 5).

Multivariate logistic regression was done to predict sex from all sternal measurements in the studied cases. A highly significant difference was found with manubrium width, manubrium length, body length, combined length, sternal index, width of body at the 1st sternal depression and width of body at the 3rd sternal depression where ($p<0.001$) and a significant difference was found with width of sternum at supra sternal notch where ($p<0.03$) as shown in (Table 6).

Also the percentage of correct prediction of sex is calculated for both males and females by receiver operating characteristic (ROC) analysis:

For the manubrium width the data demonstrated a great precision regarding sex prediction. The study results indicated a cut-off value for manubrium width of >60.8 regarding sex determination which corresponded to 76% sensitivity, 92% specificity and 88.4% accuracy. Thus, values less than 60.8 indicated with great probability that these measurements are for that female as shown in (Table 7).

As regard the manubrium length the study results indicated a cut-off value for the manubrium length of >42.3 regarding sex determination which corresponded to 100% sensitivity and 56% specificity and 80.6%

accuracy. Thus, values less than 42.3 indicated with great probability that these measurements are for that female as shown in (Table 7).

For the sternal body length the data demonstrated a great precision regarding sex prediction. The study results indicated a cut-off value for the sternal body length of 79.9 regarding sex determination which corresponded to 100% sensitivity, 100% specificity and 100% accuracy. Thus, values less than 79.9 indicated with great probability that these measurements are for that female as shown in (Table 7& Figure 6).

As regard the combined sternal length the data demonstrated a great precision regarding sex prediction. The study results indicated a cut-off value for combined sternal length of 126.2 regarding sex determination which corresponded to 100 % sensitivity, 100% specificity and 100% accuracy. Thus, values less than 126.2 indicated with great probability that these measurements are for that female as shown in (Table 7 & Figure 7).

For the sternal index the data demonstrated a great precision regarding sex prediction. The study results indicated a cut-off value for sternal index of ≤ 50.31 regarding sex determination which corresponded to 76% sensitivity, 84% specificity and 85.5% accuracy. Thus, values less than 50.31 indicated with great probability that these measurements are for that male as shown in (Table 7).

As regard the width of sternal body at 1st sternal depression (Csw1) revealed that the data demonstrated a great precision regarding sex prediction. The study results indicated a cut-off value for width of sternal body at 1st sternal depression (Csw1) of >26 regarding sex determination which corresponded to 50% sensitivity, 92% specificity and 74.5% accuracy. Thus, values less than 26 indicated with great probability that these measurements are for that female as shown in (Table 7).

The results of the width of sternal body at 3rd sternal depression (Csw3) were as follow: the cut-off value of >30.2 regarding sex determination which corresponded to 100% sensitivity, 100% specificity and 89.4% accuracy. Thus, values less than 30.2 indicated with great probability that these measurements are for that female as shown in (Table 7).

As regard the width of sternum at supra sternal notch. The study results indicated a cut-off value for supra sternal notch width of >23.4 regarding sex determination which corresponded to 66% sensitivity, 66% specificity and 63.4% accuracy. Thus, values less than 23.4 indicated with great probability that these measurements are for that female as shown in (Table 7).

Table (1): Sex distribution among different age groups of the studied cases (males and females) (N=100) by using t-test.

Age groups	Male		Female		Total		p- value
	N	%	N	%	N	%	
25-30 Years	10	20	12	24	22	22	0.658
31-35 Years	7	14	6	12	13	13	
36-40 Years	16	32	11	22	27	27	
41-45 Years	17	34	21	42	38	38	
Total	50	100	50	100	100	100	

	Male	Female	P-value
Mean ±SD	37.2 ± 6.2	37.1 ± 6.6	0.926

N= number. SD= Standard deviation.

Table (2): Manubrium width and length among the studied cases (males and females) (N=100) by using t-test.

Parameters		Male	Female	P-value
Manubrium width	**Range**	44.6 – 87	40 – 67.7	<0.001*
	Mean ±SD	66.4 ± 8.6	54.3 ± 6.002	
Manubrium length	**Range**	42.6 – 54	35.5 – 48.6	<0.001*
	Mean ±SD	47 ± 2.8	42.3 ± 3.9	

* Highly significant statistical difference at P<0.001
SD=standard deviation.

Table (3): Sternal body length among the studied cases (males and females) (N=100) by using t-test.

Parameters		Male	Female	P-value
Sternal body length	**Range**	91.4 – 104.2	71.1 – 79.9	<0.001*
	Mean ±SD	98.3± 2.7	76.9 ± 2.4	
Combined sternal length	**Range**	140.9 – 149.9	111.2 – 126.2	<0.001*
	Mean ±SD	145.3± 2.3	119.3 ± 4.7	
Sternal index	**Range**	41.4 – 57.1	44.4 – 65.5	<0.001*
	Mean ±SD	47.8± 3.94	55.1 ± 5.2	

* Highly significant statistical difference at P<0.001
SD=standard deviation.

Table (4): Width of sternal body at the 1st sternal depression among the studied cases males and females) (N=100) by using t-test.

Parameters		Male	Female	P-value
Csw1	**Range**	20.8 – 35.4	20.1 – 27.9	<0.001*
	Mean ±SD	26.4± 3.8	23.3 ± 2.2	
Csw3	**Range**	23.7 – 48.9	23.6 – 30.2	<0.001*
	Mean ±SD	33.6± 5.7	26.9 ± 2.1	
Width of sternum at supra sternal notch	**Range**	15.8 – 33.4	12 – 33.4	<0.001**
	Mean ±SD	25.002 ± 3.9	23.2 ± 4.3	

CSW1: corpus sternal width 1. **CSW**3: corpus sternal width 3 .

Table (5): Discriminant function equations and cross-validated classification accuracies for sternal dimensions of the studied cases.

Sex		Predicted Sex		Percentage Correct
		Male	**Female**	
Observed	**Male**	44	6	88
	Female	4	46	92
Overall Percentage				90

Table (6): Multivariate logistic regression for prediction of sex from sternal dimensions of the studied cases

Measures	B	Expontial (B) Odds ratio	95.0% C.I. for EXP(B) Odds ratio	P-value
Manubrium width	-0.2	0.8	0.74-0.87	<0.001**
Manubrium length	-0.4	0.7	0.56-0.79	<0.001**
Body length	-1.5	1.3	0.0-0.3	<0.001**
Combined sternal length (CL)	-1.3	3.5	0.0-0.4	0.001**
Sternal index	0.3	1.4	1.2-1.5	<0.001**
CSW 1.	-0.3	0.7	0.6-0.8	<0.001**
CSW 3.	-0.6	0.5	0.4-0.7	<0.001**
Width of sternum at Supra Sternal notch.	-0.1	0.9	0.8-0.9	0.034*
Constant	53.485	-	-	<0.001*

CSW1: corpus sternal width 1. **CSW3**: corpus sternal width 3 .

Table (7): Receiver operating characteristic (ROC) analysis of the studied sternal measurements of both males and females for optimum cut off points in predicting sex.

Variables	Cut off	Sensitivity	Specificity	PPV	NPV	Accuracy
Manubrium width.	>60.8	76.0	92.0	90.5	79.3	88.4%
Manubrium Length.	>42.3	100.0	56.0	69.4	100.0	80.6%
Body length.	>79.9	100.0	100.0	100.0	100.0	100%
Combined sternal length.	>126.2	100.0	100.0	100.0	100.0	100%
Sternal index.	≤50.31	76.0	84.0	82.6	77.8	85.5%
CSW 1.	>26	50.0	92.0	86.2	64.8	74.5%
CSW 3.	>30.2	70.0	100.0	100.0	76.9	89.4%
Width of sternum at supra sternal notch	>23.4	66.0	66.0	66.0	66.0	63.4%

CSW1: corpus sternal width 1. **CSW3**: corpus sternal width 3 .

PPV: positive predictive values. **NPV:** negative predictive values.

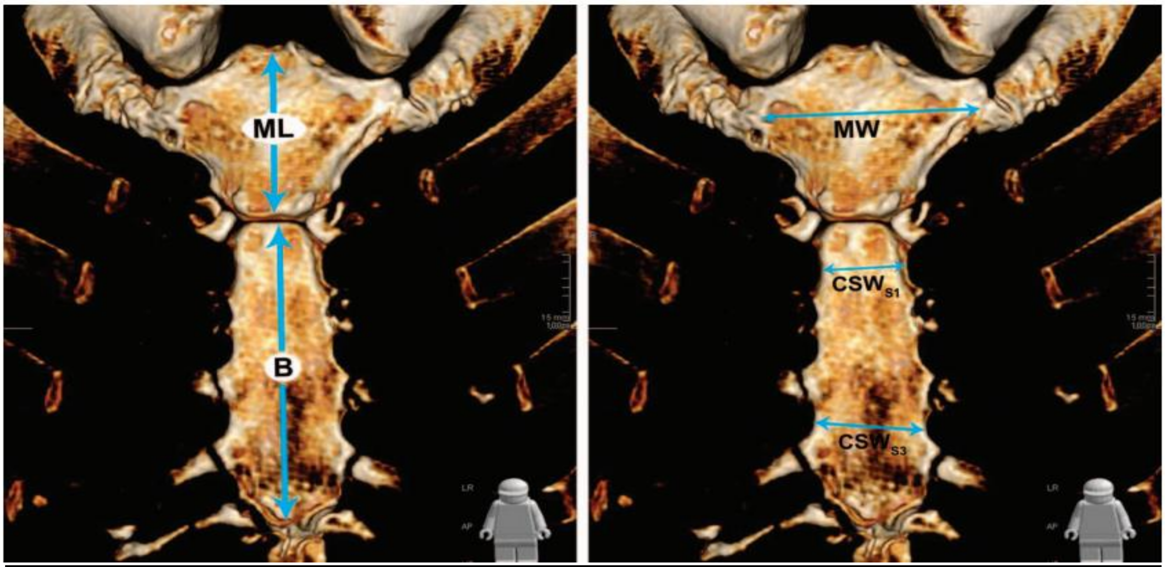

Figure (1): Reconstructed three – dimensional computed tomography of sternum showing the measurements used in the present study. (**ML**) manubrium length; **(MW)** manubrium width. **(B)** sternal body length; **(Csw1)** width of sternum at 1st sternal depression; **(Csw3)** width of sternum at 3rd sternal depression.

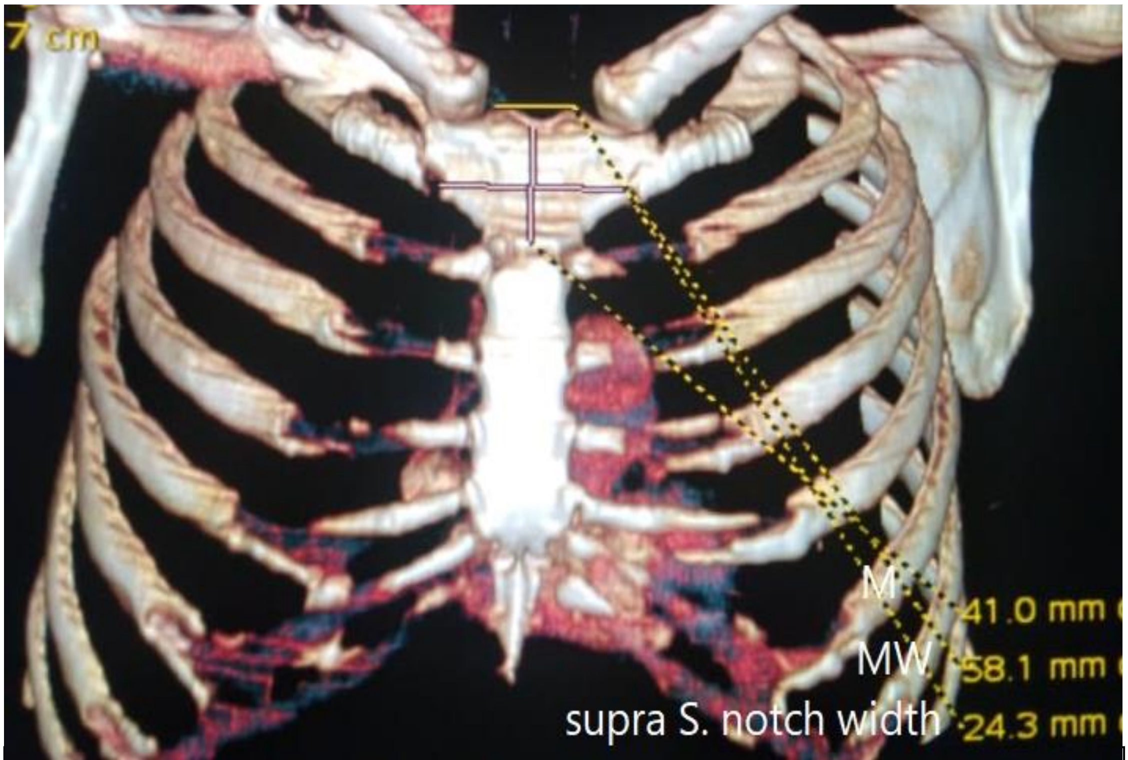

Figure (2): Computed tomography imaging showing manubrium width, manubrium length and width of supra sternal notch in one of the **male** participants; **(M)** manubrium length; **(MW)** manubrium width.

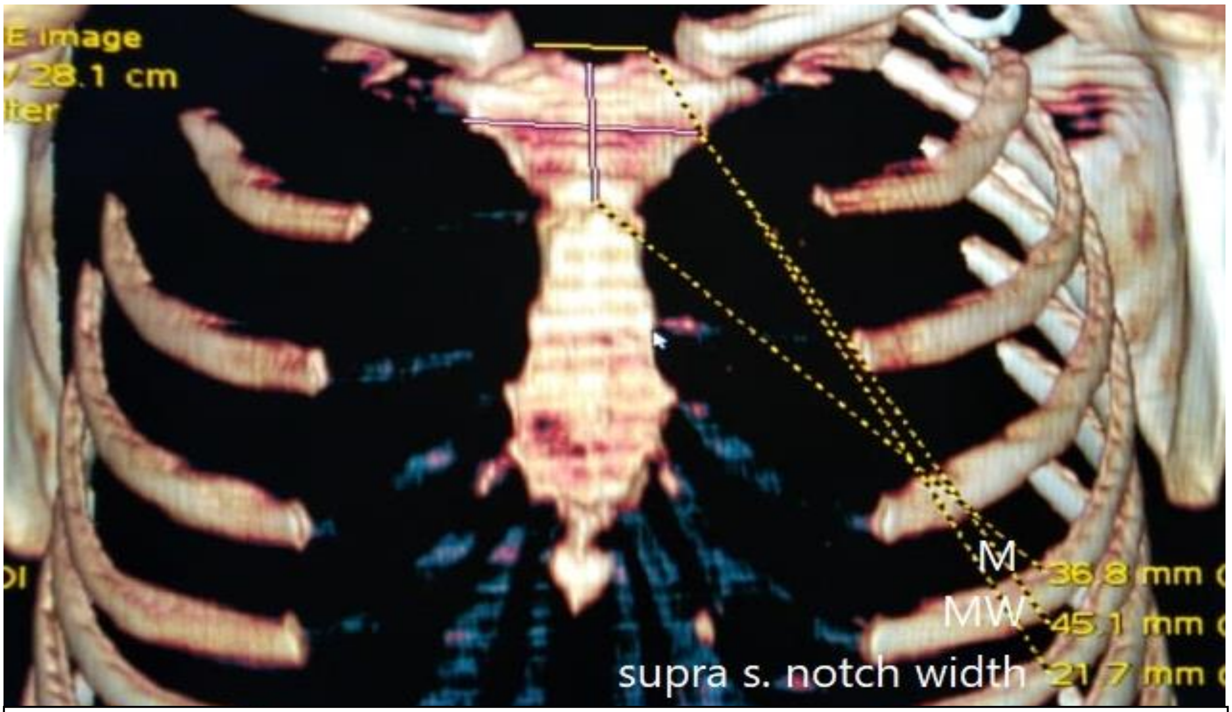

Figure (3): Computed tomography imaging showing manubrium width, manubrium length and width of supra sternal notch in one of the **female** participants; **(M)** manubrium length; **(MW)** manubrium width.

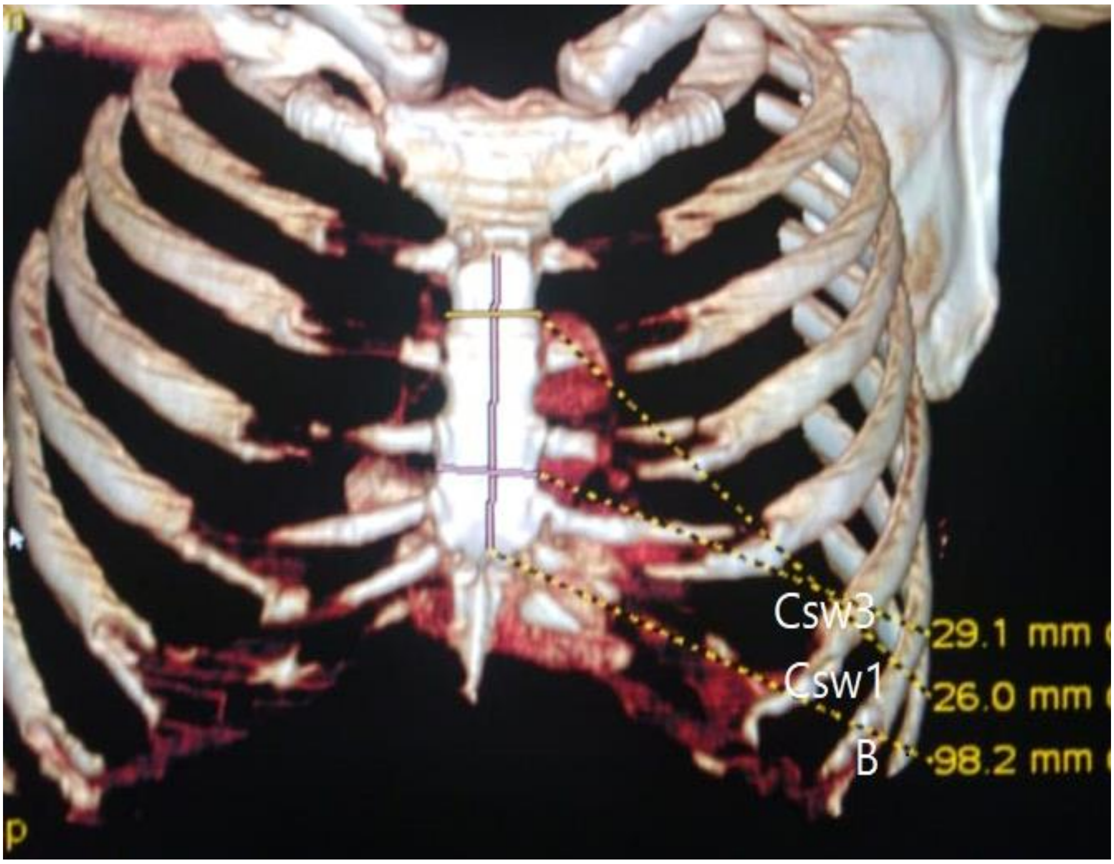

Figure (4): Computed tomography imaging showing sternal body length and width of sternum at 1st and 3rd sternal depression in one of the **male** participants; **(B)** sternal body length; **(Csw1)** width of sternum at 1st sternal depression; **(Csw3)** width of sternum at 3rd sternal depression.

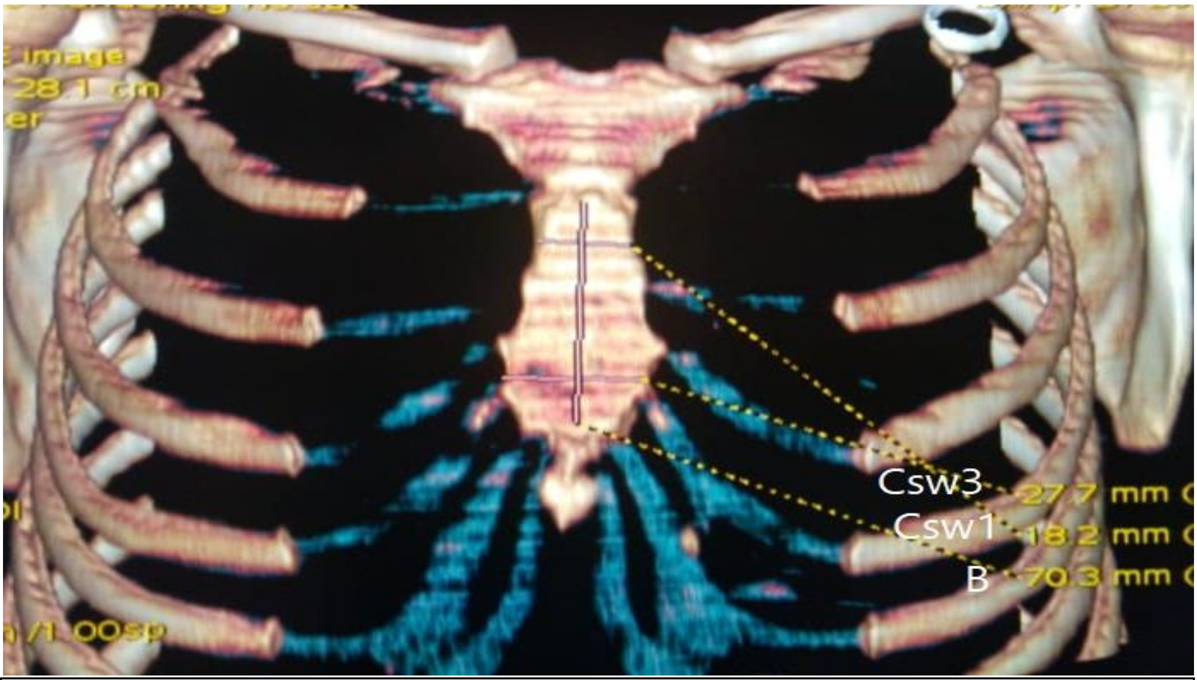

Figure (5): Computed tomography imaging showing sternal body length and width of sternum at 1st and 3rd sternal depression in one of the **female** participants; **(B)** sternal body length; **(Csw1)** width of sternum at 1st sternal depression; **(Csw3)** width of sternum at 3rd sternal depression.

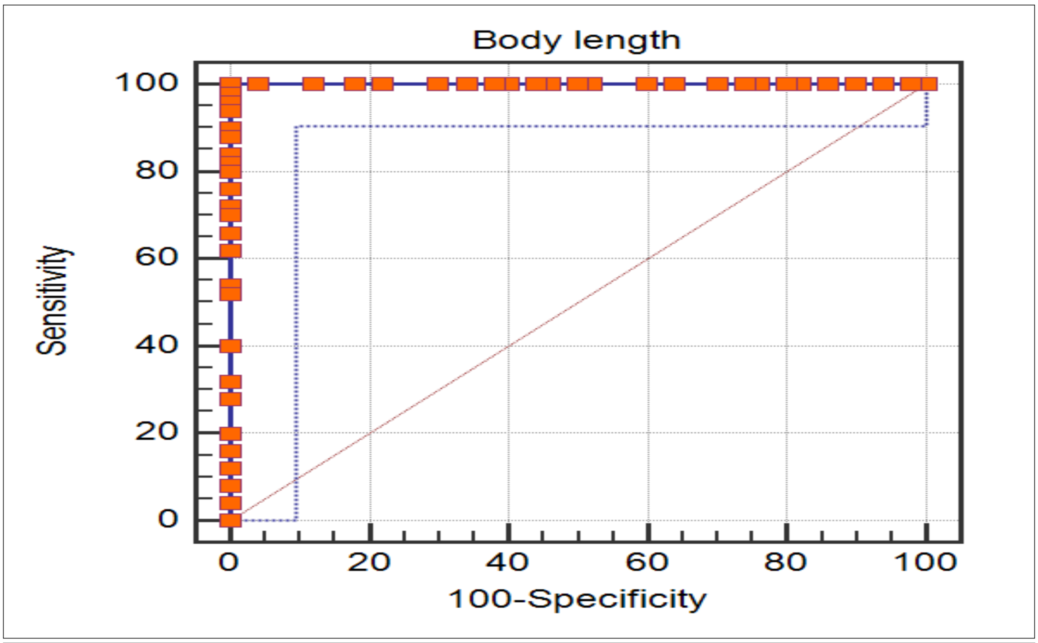

Figure (6): Receiver operating characteristic (ROC) curve of the sternal body length for optimum cut off points in predicting sex

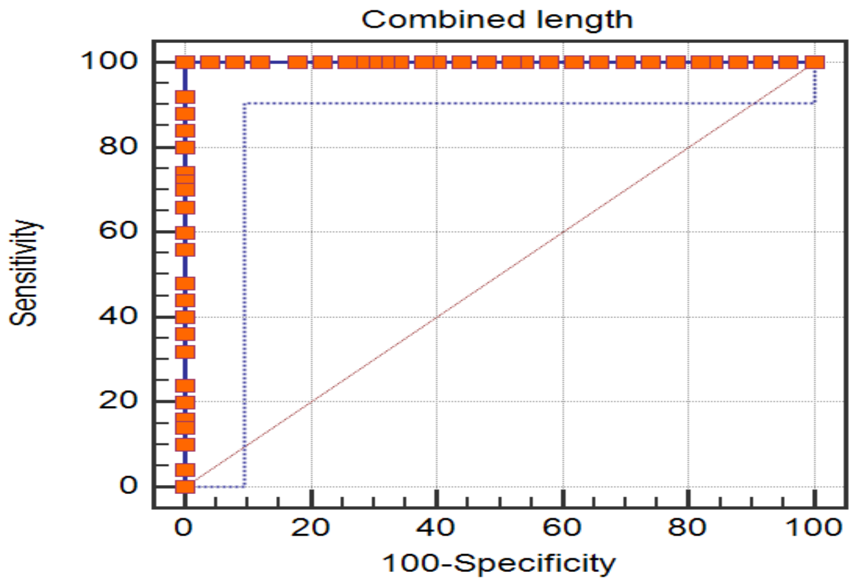

Figure (7): Receiver operating characteristic (ROC) curve of the combined sternal length for optimum cut off points in predicting sex.

III. DISCUSSION

In different cases of intentional dismembering and disfigurement, the sternum can be obtained intact, as it is protected within the chest. So, the researches upon the sternum for identification purposes may be more valuable and beneficial than the other body bones **(Chandrakanth et al., 2014).** Many studies have reported that the skeletal criteria differ between populations, so there is a demand to put particular standards for the different populations (***Suazo et al., 2008 and Saini, 2013)***.

The present study included 100 adult subjects (50 males and 50 females). Their ages ranged from 25 to 45 years because sternal parts fuse with each other from below upward which begins at puberty and is completed by 25 years of age **(Winniecia, 2014).** Also to avoid effect of hormonal changes in menopausal females **(Francesquini et al., 2007).**

In the present work, no significant statistical difference was found in the mean value of age between males and females as regard different sternal measures.

The results of the current study showed that the manubrium width, manubrium length and width of sternum at supra sternal notch in males were larger than females.

The present results were in agreement with the results obtained by **Franklin et al. (2012)**, study for sex estimation from sternal dimensions in a Western Australian population using C.T scan. The authors reported that the mean values of the manubrium width and length in males were clearly significantly larger than females.

Similar results were reported in the study of **Ankit et al. (2013),** in population of Saurashtra region in Indian using dries sternum concluded that there was statistically significant increase in mean values of length of manubrium, in males in comparison with females.

The current data agreed with the results stated by **Rajendra et al. (2017)** who found that the sternal width at suprasternal notch and at the level of fourth rib in Delhi's population were larger in males than females.

The current results showed that the sternal body length, combined sternal length, width of body at the 1st sternal depression and width of body at the 3rd sternal depression were larger in males in comparison with females.

In a harmony with the results of the present work a study of **Changani et al. (2014)**, for estimation of sex from sternal measurements by CT in Indian population found that sternal body length, and combined length of manubrium and sternal body were larger in males than females.

Torimitsu et al. (2015), who used M.D.C.T. for determination of sex in Japanese cadavers depending on sternal measurements found that the mean values of the male samples were significantly larger than the female samples for sternal body length, width of body at the 1st and 3rd sternal depression. So that sternal body length (B) could a reliable indicator of sex. These results suggest that sternal body can be used for sex determination if it is the only bone remain.

The present results demonstrated that the sternal index was larger in females as compared to males. The sternal index is derived by dividing the length of manubrium by the length of sternal body and multiplying it by 100.

In agreement with the present findings **Macaluso and Lucena (2014),** who used chest plate radiographs to estimate sex from sternal dimensions in Spanish. They found that sternal index was larger in females than males.

In contrast to the present work **Zhang et al. (2015),** study for sexual dimorphism of sternum using C.T. between Western Chinese and reported that the sternum index did not differ significantly between both sexes. This could be explained by differences in nutritional, geographic, and racial features **(Patil and Mody, 2005).**

In the present study the discriminant function equation and cross validated classification accuracies can predict sex in the studied sample of Sohag governorate population by (88%) in males and (92%) in females with average (90%).

A study of sexual dimorphism in Spanish population in which the sternal dimensions were obtained from posteroanterior digital radiographs of the chest plate of living Spanish individuals. Results demonstrated that all parametrs of the manubrium and mesosternum, combined length, and sternal index were significantly different between males and females in this population. Discriminant function analyses including many of these parameters, alone or in combination, proved sex classification accuracy rates more than 80.0%, with associated sex biases less than 5.0%. When a complete sternum is present, a stepwise procedure was used and revealed the highest correct sex classification rate at 89.7% **(Macaluso and Lucena, 2014).**

In a harmony to the present results **Ahmed et al. (2017**), established a study for estimation sex in Saudi population depend on sternal measurements using C.T imaging. They concluded that the sex prediction accuracy ranged from (62.5% to 89.5%). The combined sternal length and sternal area were the most dimorphic variables with classification accuracies of 89.5% and 88% respectively. while the sternal body length had a classification accuracy of 85% and zero sex bias.

In the current study, the Receiver Operator Characteristic analysis (ROC) was used to evaluate the validity of the tested measurements. For each parameter, assessment of the cut-off value between sensitivity and specificity was performed.

The ROC analysis in present study revealed that sternal body length and combined length were the most specific (specificity 100 %) and the most sensitive (sensitivity 100%) with accuracy 100% to discriminate between both genders.

Additionally, the prediction rate for combined length of manubrium and sternal body (CL) was over 85%, suggesting that CL is a reliable parameter for sex determination.

The classification accuracy for CL in the present study was agreed to the results reported by **Macaluso and Lucena (2014),** in Spanish population recorded that the prediction success rate of sex by using CL was 81.0%.

Similarly **Zhang et al. (2015),** recorded that the manubrium width (MW) provided a sex prediction success rate of 76.1%. Sternum body provided a prediction success rate of 78.4%. Combined length (M + B) correctly estimated the sex of 82.4% of the individuals in the study sample, with a sex bias of 4.4%

In contrast to the present work **Adhvaryu et al. (2013),** and **Changani et al. (2014)**, reported that sternal body length (B) may be an unreliable sex predictor as the most of male and female samples were falling into overlapping zone. The differences between the studies has been attributed to various factors either genetic, environmental, or socioeconomic one. For example, physical activity affects the amount and duration of growth, hormonal levels and muscle mass **(Krogman and İşcan, 1986; Scheuer, 2002).**

Conclusion:

The present work concluded that all sternal measurements which was assessed were statistically significant higher in males except sternal index which was higher in females. Among all sternal measurements the sternal body length and combined length were the best discriminate variables between genders with overall accuracy of 100% both females and males.

IV. RECOMMENDATIONS

- Selection of a wider range for age group to correlate between different age groups and the best parameter in determination of sex in each age group.
- It is better to use larger sample size than that was chosen in the present work to have the availability to determine a specific range and cut off point to the different parameters.
- It is recommended to use another types of radiations as MRI, micro-CT and Nano-CT these types will be more accurate.

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الملخص العربي

تحديد الجنس من قياسات عظم القص باستخدام التصوير المقطعي بالكمبيوتر في عينة من سكان محافظة سوهاج

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يعتبر التعرف علي الهوية أحد المعايير الهامة في الطب الشرعي خاصة في التحقيق في القضايا الجنائية والكوارث الجماعية وفي القضايا الطبية الشرعية. و يعتبر تحديد الجنس خطوة هامة في الاستعراف علي الاشخاص ويمكن أن يتم ذلك من خلال فحص العظام اما بقياسها متريا مباشرة أو من خلال صور الأشعة خاصة في حالات صعوبة الاستعراف كتقطيع الجثة و التشوه والانفجارات. في مثل هذه الحالات يمكن للطبيب الشرعي الاعتماد على قياسات بعض العظام. يتميز عظم القص البشري بالحفاظ على سلامته حتى في حالة التدمير المتقدم للهيكل العظمي ، نظرًا لموقعه المحمي داخل الجسم.**الهدف من الدراسة**: صممت هذه الدراسة لتحديد الجنس من القياسات المختلفة لعظم القص من خلال التصوير المقطعي بالكمبيوتر متعدد القطاعات. **طريقة الدراسة**: تضمنت الدراسة الحالية 100 مشارك بالغاً 50 منهم من الذكور و 50 من الإناث. **النتائج**: أوضحت الدراسة الحالية انه لا يوجد فرق ذو دلالة إحصائية بين الذكور والإناث فيما يتعلق بالعمر. كما أظهرت المقارنة بين مجموعات الذكور والإناث أن مجموعة الذكور لديها قيم أعلى ذات دلالة إحصائية لجميع قياسات عظمة القص في الدراسة باستثناء معامل عظمة القص كان أعلى في الإناث. أظهرت معادلة الانحدار المتعددة أن التنبو بنوع الجنس من قياسات عظم القص كان صحيحا بنسبة (90%) 88 % للذكور و 92 % للاناث .وقد تم تحديد قيمة قطعية لكل قياس ، وكذلك تحديد نسبة الحساسية والخصوصية وتبينت الدراسة إلي أن طول جسم عظمة القص وطول رأس وجسم عظمة القص هما الأكثر تحديدًا (نسبة الخصوصية 100٪) و الأكثر حساسية في تحديد الجنس (نسبة الحساسية 100٪). من بين جميع القياسات القصية ، كان طول جسم عظمة القص و طول رأس وجسم عظمة القص هما الأفضل في تحديد الجنس بدقة إجمالية 100٪ لكل من الإناث والذكور.