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Evaluation of Relation of Dimensional Measurement of Different Anatomic Skull Structures to Determine Sexual Dimorphism in Cone Beam CT Images of an Iranian Population

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ABSTRACT

Several bones have been examined for identification and determining the sex in the corpses, such as skull bones. Nowadays, CBCT images have high importance, since they have ability to produce images in different designs, which increase the efficiency of diagnosis. Thus, the objective of this research was to evaluate the dimensional measurement of different anatomic skull structures in determining the sexual dimorphism accuracy in cone beam CT images in an Iranian population. In this descriptive-analytical study, 102 patients, admitted to Oral and Maxillofacial Radiology Department of Tabriz Faculty of Dentistry for evaluation by CBCT were examined. For this purpose, landmarks of frontal and maxillary sinus, mandible and foramen magnum were measured and finally analyzed by SPSS software to determine the sexual dimorphism accuracy of the measurements. The results of this research revealed that in terms of difference between males and females, the greatest difference belonged to different parts of the maxillary sinus. Results of different parts of the right and left frontal sinus in this research revealed no difference among them. Moreover, the sexual dimorphism accuracy from frontal sinus was estimated about 76.7% in this research. Images related to CBCT of frontal sinus, maxillary sinus, and mandibular landmarks can be helpful in sex determination. The results of sex determination accuracy by landmarks measured in this research revealed that the highest sex determination accuracy belonged to size of ramus height with 81%, and the lowest accuracy belonged to total width of the frontal sinus with 45%. In addition, considering all the variables at the same time, the predictive power was found 100%.

Key words: Sex Determination, CBCT, Frontal Sinus, Maxillary, Mandible,Foramen Magnum

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INTRODUCTION

In most of animal species, there is a significant difference between the adult males and females in terms of the mean body size and this phenomenon is known as the Sexual Size Dimorphism (SSD) and this phenomenon is also seen in humans [1].

Several bones have been examined for identification and sex determination in the corpses, including pelvic bone, skull bones such as frontal sinus, mandible bone, and antegonial notch depth [2-4]. Computed tomography (CT) and cone beam CT provide more valid measurements in comparison with simple radiographies [2]. Recently, CBCT images have found more importance in dentistry. They can produce images in different designs, which increase the efficiency of diagnosis [5]. These multi-planar images help us evaluate the

morphology, position, shape, size, and diversity in the anatomic structures of the oral and upper jaw areas easily [2, 6]. These devices are used to measure the landmarks related to head and face bones.

The morphology of the frontal sinus remains stable and unchanged until the old age, when atrophic changes occur [7, 8]. Some studies have reported that the frontal sinus structure is unique and even comparable to the fingerprint [7, 9]. The mandible bone (the lower jaw bone), as one of the strongest and most durable skull bones in humans, shows a high degree of sexual dimorphism [10]. One research was conducted in 2015 under the title of mandible analysis to evaluate the sexual differences using anthropometric measurements of mandible images obtained by CBCT [10]. Due to the importance of sex determination in identification, there is need to examine the anatomic landmarks in other areas to increase the study accuracy. The mandible bone in this research can be very useful, since this bone is the most durable bone of the face and maintains its shape better than other face bones. In addition, this bone is the strongest and the largest bone of the face [4].

The mandible deformation depends on its dynamic environment. Moreover, due to the ease of imaging of the mandible, this bone is considered as an important tool in identification through radiology [11]. In addition, based on the different studies and reports, it has been found that maxillary sinuses remain intact over the years, but bones of skull and other parts may be severely deformed due to burning and accidents. Thus, maxillary sinuses can also be very useful for identification [12]. In another study, Thiago Gamba et al examined the sex determination by anthropometric analysis of the Mandible CBCT images. The results of this research revealed that the level of sexual dimorphism accuracy was about 95%. Accuracy level was estimated at 93% for males and 94.7% for females [13].

In another study conducted by Kharoshah et al in 2010 on Egyptian population, sex determination was performed by mandible. The results revealed that the prediction accuracy of this model was about 83.9% for all people studied. The prediction accuracy was about 83.6% for males and 84.2% for females [14]. Given the inconsistency of the results and the shortcomings of the conducted studies in terms of sample size, the accuracy of the study or the nature of the samples, conducting this research seems to be necessary. In addition, as researchers used only one kind of landmark or measured dimensions of one bone and they estimated sex with lower coefficients, the current research was conducted to introduce an optimal method for the aim of integrating measurements of different landmarks in different anatomic areas in order to enhance the accuracy in an Iranian population.

MATERIALS AND METHODS

In this descriptive-analytical study, 102 patients, admitted to the Oral and Maxillofacial Radiology Department of Tabriz Dental School for the aim of evaluation by CBCT, were examined. The images were prepared by the NewtomVGi cone beam device (Verona / Italy) in the maxillofacial radiology department. Initial and final reconstruction was performed by NNT Viewer version 2.21 software. Then, the data obtained from CBCT, were entered into NNT viewer version 2.21 software. All patients with a history of trauma or fracture or any pathological conditions in the head and face (frontal sinus, maxillary and mandible) or those with a history of surgery in these areas or lacking images with desired quality were excluded from the research.

Total width of the frontal sinus, the width and height of each sinus, the distance of the longest point of two sinuses, and the anterior posterior dimension of each sinus were measured. The total width of sinus was placed at the last two sinuses distance, without considering the bone edges of them, the maximum distance between the farthest points were measured. It should be noted that all these images were obtained from the same cuts in coronal and axial sections. The width and length of each of the maxillary sinuses was measured on the axial plane of the image and the height of each sinus was measured in the coronal plane of the image. Maximum distance between the farthest points was also measured.

In dimensional measurements of some mandible bone landmarks, gonial angle (GA), ramus length (RL), gonion-gnathion length (GGL), ramus minimum breadth(MRBr), and antegonial notch depth (AD) were measured in the sagittal plane of image and bi-condylar breadth(BicBr) and bi-gonial breadth(BigBr) in axial plane of image. At first, gonion, condylion, and gnathion points were determined, in which the gonion is the lowest, posterior, and lateral point on the external angle of the mandible. The distance between the

anatomic landscapes of the condylion and gonion is ramus length. The distance between gonion and gnathion is considered as gonion- gnathion length, and the shortest width of mandible ramus and antegonial notch depth is the vertical distance from the deepest point of the antegonial notch to the mandible plane. The dimensional measurements were performed in mm, and finally, the measurements were inserted in the checklist (attachment).

In order to dimensional comparing of the frontal sinuses, the maxillary sinuses, some mandible bone landmarks and foramen magnum in the two sexes, if the distribution of data is normal, independent t-test is used, and if the data are not normal, its non-parametric equivalent, that is, U-Mann-Whitney test is used. The software used in this research was SPSS 17 and the significance level was considered to be P <0.05.

RESULTS

In this research, 102 people participated, which 51 of them were female and 51 were male. The mean age of participants was 46.65± 12.72 years, and none of the subjects had a history of systemic disease and drug use. The descriptive statistics of the measurements are shown in Table 1.

Measured landmarks		Mean ± SD
age		40.65 ± 12.72
Frontal sinus		
Frontal sinus height in the coronal view	right	19.58 ± 5.78
	left	19.59 ± 4.89
Frontal sinus width in axial view	right	27.73 ± 10.04
	left	29.31 ± 14.05
The posterior anterior dimension of frontal sinus in the axial axis	right	16.08 ± 5.67
	left	16.41 ± 5.02
Total width of frontal sinus		53.92 ± 13.5
Maxillary sinus		
Maxillary sinus height in the coronal view	right	36.77 ± 6.24
	left	36.9 ± 5.84
Width of maxillary sinus in axial view	right	24.3 ± 5.55
	left	24.68 ± 5.58
Posterior anterior dimension of maxillary sinus in axial view	right	37.89 ± 4.54
	left	37.81 ± 4.93
Mandible bone		
ramus height		57.9 ± 6.4
Gonial angle		128.92 ± 15.68
Gonion- gnathion length		75.15 ± 5.66
ramus minimum width		29.45 ± 3.37
Bi-gonial width		91.66 ± 7.23
Bi-condylar width		114 ± 9.04
Antegonial notch depth		2.57 ± 1.65
Foramen Magnum		
Foramen Magnum width		30.45 ± 2.48
Foramen Magnum length		35.06 ± 3.9

Then, paired t-test was used to compare the landmarks in right and left sides. The results revealed no statistically significant difference between any of the two sides (P-value> 0.05). The highest difference between the left and right sides was related to the frontal sinus width in the axial view with difference of 1. 57 units that was more in the right side and the lowest difference was related to posterior anterior dimension of maxillary sinus in the axial view with the difference of 0.08 units that was more in the left side. Independent Samples T-test was also used to compare the landscapes between males and females due to the normal distribution of all the data and the results revealed significant difference between the anterior posterior dimensions of the frontal sinus in the right axial view, between the posterior anterior dimension of frontal sinus in the left axial view, all dimensions in the maxillary sinus, all dimensions in the mandible bone, except for the gonial angle as well as the length and width of the foramen magnum (P-value <0.05).

Finally, logistic regression analysis and Classify Test were used to determine the accuracy of sex

determination by landmark measurements. The results revealed that the highest accuracy of the sex determination belonged to size of the ramus height with value of 81%, and the lowest accuracy belonged to size of total width of the frontal sinus with value of 45%. The highest level of accuracy in sex determination was predictable by the size of ramus height with values of 82.4% and 80.4% in males and females, respectively. The general accuracy with respect to the landmarks measured in the frontal sinus, maxillary sinus, mandible bone and foramen magnum is presented in Table 2. In this research, it is seen that the highest accuracy was related to mandible bone with 89% and the lowest accuracy was related to foramen magnum with 71%. The accuracy of sex determination based on the total measurements was estimated 100%.

Table 2: The general accuracy of sex determination

	Accuracy level		General accuracy
	female	male	
Frontal sinus	83.3%	76.6%	81.4%
Maxillary sinus	75.5%	72%	73.7%
Mandible bone	89.4%	89.8%	89.6%
Foramen magnum	76.5%	66.7%	71.6%
total	100%	100%	100%

DISCUSSION AND CONCLUSION

Frontal and maxillary sinuses as well as mandible bones can be very helpful in forensic medicine in order to estimate the age, sex, and race in decomposed and burned corpses. Studies on sex dimorphism provide much information on evolution of the population and even individuals [15]. Race differences in different bones such as frontal sinus and maxillary sinus are considered important in this regard, and results are valid only in the race investigated in each research. Thus, it is necessary to examine the bone dimensions of the frontal and maxillary sinuses as well as the mandible bone landmarks and their different proportions in different races [2, 10, 11, 14].

CBCT development in the preparation of three-dimensional images was a great achievement for orthodontic diagnoses, which prepared high-quality images in short time and at the lowest radiation rates compared to conventional CTs [16]. Given lack of accurate studies on the measurement of frontal and maxillary sinuses, different landmarks of mandible bone and contradictory results of studies conducted in this regard, and its importance in identification and forensic medicine, this research was conducted to determine and evaluate dimensional measurements of different anatomic structures of the skull in determining the accuracy of sexual dimorphism in cone beam CT images in an Iranian population. Results of different parts of the right and left frontal sinus revealed no difference among them. However, in other studies conducted in this regard, the left side was more than the right side in some cases [17], and in the study conducted by Camargo et al in 2007; the right was more than the left side [18]. The results of the research carried out by Jose Marcos Ponde et al and Rubira-Bullen [19] revealed that the frontal sinus dimensions were smaller in the right side than them in the left side in the populations studied. Such differences suggest the independent evolution and development of sinuses [17]. One main reason for this type of race differences among different populations might be due to genetic differences involved in the process of bone development and formation [20].

Mandible is one of the strongest and most durable skull bones in humans with a high degree of sex dimorphism. In the study conducted by Gamba et al., five dimensions (ramus length, gonion-gnathion length, gonial angle, bi-gonial width, and bi-condylar width) were examined which these dimensions were more in males compared to females [10]. Results of our research with regard to dimensions of mandible bone landmarks also confirmed the results of the study conducted by Gamba et al. However, gonial angle was more in females than that in males in this research. In addition, the results of the research conducted by Gamba et al indicated that the accuracy of sexual dimorphism was estimated at 95%, which the accuracy was 93% for males and 94.7% for females. However, in our study, the highest prediction accuracy was related to total height of ramus and with 89.6%, which it was 89.8 and 89.4 for males and females, respectively [10].

In the research conducted by Osato et al in 2012 to predict the sex based on mandible and gonial angle parameters, it was revealed that the sexual dimorphism is seen more for mandible cortical width (MCW) and notch antegonial depth (AD) in males compared to females. The results also showed significant difference in the distribution of three mandibular indices between the two GA groups in males [3]. The results of these studies suggest that mandible different morphology can be effective in the size of the gonial angle (GA) and sex type. Research results also revealed that all sizes in maxillary sinus are significantly different between men and women, and in all of them, the dimensions of males were more than those of females. In the study conducted by Tambawala et al under title of sex difference of maxillary sinus using CBCT, it was revealed that general values of parameters were more in males compared to those in females [21]. Moreover, in the research conducted by Yasar Teke et al in 2007, the results showed that the maxillary sinus dimensions were lower in females compared to those in males. The sex predictive value was estimated to be about 69% [22]. In justifying the differences of results of different studies, it might be stated that race issues might be involved, as studies have been conducted in different countries.

CONCLUSION

The results of this research revealed that the highest difference between the males and females was related to different parts of the maxillary sinus. In addition, the results of sex determination accuracy by landmarks measured in this research revealed that the highest accuracy of sex determination belonged to the size of ramus height with value of 81%, and the lowest accuracy

belonged to total width of the frontal sinus with value of 45%. Considering all the variables at the same time, the prediction and estimation power is also 100%.

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