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Analysis Sex Determination to Forensic Aspect Use Maxillary Sinus Measurement by CBCT: A Pilot Study

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Abstract: *Analysis sex determination is an important to identification unknown person. CBCT scan can be used to analyzing a dimension in skeletal and for sex estimation when other methods are inconclusive using morphometric aspects, for example through maxillary sinuses can be performed the sex prediction. This study was conducted to estimate the size of the different dimensions of the maxillary sinus to sex determination of an individual by measuring the height, width, length and volume of the maxillary sinus using CBCT in Indonesia. The study of CBCT analysis scan from 20 subject (10 male and 10 female) shows that the potential high score parameter of p value is 0,00 < 0,05 on SI right, MSV right, AP left and MSV Left. It can be used to the prediction of sex determination. Binary logistic regression can be performed 85% from four parameter (SI right, MSV right, AP left and MSV Left) and the result more likely to male. Different result of discriminat function analysis showed the prediction to sex determination use maxillary sinus have percentage 80% to both group. The maxillary sinus measurements are valuable parameters for sex determination in forensic odontology, with a relatively good accuracy rate.*

Keywords: *sex determination; maxillary sinus; forensic odontology; dentistry; cone beam computed tomography*

I. Introduction

Sex determination from bones is based on their morphological and morphometric features. A combination of both morphological and morphometric features can provide the most accurate results. Fingerprints are an accurate, broadly applied identification method (Henrique et al, 2015). However, in some cases, this collection becomes difficult. Because, the condition of bone becomes a fragmented, incomplete, or mingled state, especially in disasters such as explosions, war, natural disasters, and other mass disasters such as plane crashes. Thus, important to use denser bones, such as the maxillary sinus and thus alternating the skeletal area to be examined for sex estimation (Tambawala et al, 2016).

The maxillary sinus is a bilateral pyramidal-shaped pneumatic chamber that has the largest volume compared to other sinuses. Located in the upper jaw and in the middle there is a nasal bone and is in the lateral wall of the nose (Soman, 2019). The maxillary sinus anatomy is important in forensic odontology examination procedures. Sinus growth begins about three months in fetal development as epithelial imagination from the lateral wall of the nasal fossa. Postnatal maxillary sinus growth, according to the current literature, occurs mainly during the first three years of life and between 7-12 years. Adult growth occurs between 12-15 years (Mascpero et al, 2020).

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Radiographic examination of the sinuses has been used to identify and determine sex and heredity. Computed tomography (CT) scanning is an excellent imaging modality used to evaluate nasal cavities. This provides detailed information that is not available from standard radiography. CT measurements of the maxillary sinus are useful for supporting sex determination. Maxillary sinuses are generally greater in men than women in the contemporary human population (Kanthem et al, 2015).

Cone beam computed tomography (CBCT) provides an opportunity for use in forensic medicine. CBCT may be useful in a number of forensic contexts, because it can offer several advantages for post-mortem forensic imaging, including good resolution for framework imaging, relatively low cost, portability, and simplicity. Certain studies on 3D reconstruction, bite mark analysis, age estimation, person identification and anthropological assessment have been carried out using CBCT with promising results (Tambawala et al, 2016). Computer tomography (CT) scanning provides accurate results in the assessment of paranasal sinuses, craniofacial bones, and the degree of sinus pneumatization. In addition, images represent a series of adjacent cross-sections and three-dimensional information (Khasbage et al, 2018).

This study was conducted to estimate the size of the different dimensions of the maxillary sinus for sex determination of an individual by measuring the height, width, length and volume.

II. Research Methods

2.1 Sample

The sample for this study came from a bilateral CBCT scan of the maxillary sinus obtained in July-August 2019 at the Pramita Clinical Laboratory Surabaya, consisting of 20 subjects with bilateral maxillary sinus CBCT scans (40 maxillary sinuses) from 10 males and 10 females, between 20 - 35 years old. The criteria sample consisted of inclusion criteria in which CBCT images of the maxillary sinus scan looked good, there were no blurred or truncated maxillary sinus fragments, and there were no pathological abnormalities in the sinus region. The tool CBCT image uses the huge solio brand. This research got an ethical clearance certificate from Faculty of dental medicine, Universitas Airlangga number: 567/hreccfodm/viii/2019 and has received written informed consent from all participating.

2.2 Measurement

The observers from oral and maxillofacial radiologists measured three distances (width, depth, height) in axial and coronal view. These measurements used 3D imaging software with the On-Demand 3D application. Observers are allowed to use double magnification and modify screen brightness.

The morphometric of the maxillary sinus were performed in the following methods (Kumar et al, 2018):

a. Height/SI dimention (coronal view): The distance from the lowest point of the sinus base to the highest point (fig.1).
b. Width/AP dimention (axial view): The distance of the medial wall of the sinus to the most lateral wall of the maxillary sinus (fig. 2).
c. Depth/ML dimention (axial view): The distance from the anterior point to the posterior point of the medial wall (fig.2).
d. Maxillary sinus volume (MSV) is the total of measurements of height, width and length on maxillary sinus.

$$\text{Volume} = (SI \times AP \times ML \times 0{,}5)$$

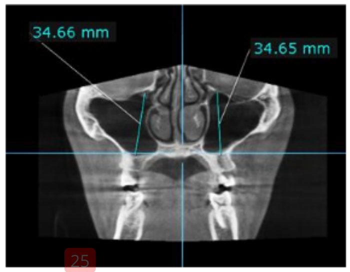

Figure 1*. Height of the Maxillary Sinus on Coronal View*

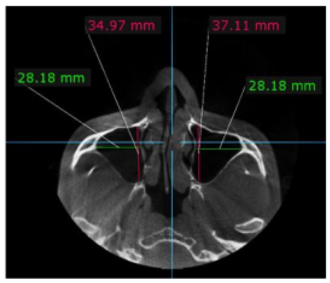

Figure 2*. Pink Color is Depth of the Maxillary Sinus and Green Color is Width of the Maxillary Sinus on Axial View*

2.3 Statistical Analysis

After measuring all dimensions, a statistical analysis was performed using SPSS version 20, with an independent t-test to determine the significance of the results of the calculated parameters, followed by significant data from the parameters, a binary logistic regression test which had a highly significant value and the coefficient of function test was performed discriminant function to all parameters used to get the calculation formula and predict the percentage of sex using the right maxillary sinus and the left maxillary sinus.

III. Results and Discussion

3.1 Results

The descriptive analysis is shown in Table 1. The quantitative data is calculated as Numbers (N), Mean, t-value, and p-value. Significant differences were observed only between all the two parameters of the right sinus and the left sinus (p value <0.05) using an independent t-test.

Table 1. Independent T test from Male and Female

	Sex	N	Mean	t-value	p-value	Sig.
SI right	M	10	3,74	3,48	0,00	S
	F	10	3,32			
AP right	M	10	3,35	1,66	0,11	NS
	F	10	3,43			
ML right	M	10	2,86	3,37	0,03	S

	F	10	2,51			
Volume right	M	10	19,32	3,52	0,00	S
	F	10	14,43			
SI left	M	10	3,62	1,97	0,06	NS
	F	10	3,28			
AP left	M	10	3,75	3,70	0,00	S
	F	10	3,40			
ML Left	M	10	2,81	2,46	0,02	S
	F	10	2,49			
Volume Left	M	10	19,86	3,52	0,00	S
	F	10	13,94			

Note: significant $p < 0,05$

In the calculation of mean (SI right, ML right, MSV right, SI left, AP left, ML left and MSV left), the female group showed statistically significant lower sinus parameter values than males. But the different result of AP right showed that the female group had a higher value than the male group.

Some significant data groups of p value can be used for analysis, logistic regression binary with the potential high score parameter of p value is $0{,}00 < 0{,}05$ is right, MSV right, AP left and MSV Left. It can be used to the prediction of sex determination shown in table 2

Table 2. Logistic Regression Co-officiants Used to Calculate Logit (β) from the Most Significant Measurements

		B	df	Sig.	Exp(B)
Step 1[a]	SI Right	-12,190	1	,155	,00
	Vol Right	,864	1	,285	2,37
	Ap Left	-11,607	1	,146	,00
	Vol Left	-,202	1	,746	,81
	Constant	74,090	1	,111	1,50E+32

Logit (β) = $\beta 0 + \beta 1X1 + \beta 2X2 + ... + \beta nXn$

Logit value could be used to male sex (βM) probability calculation using equation.

$P(M) = e^{logit}(\beta) / (1+e^{logit (Q1)})$

Female sex probability is simply Q(F) = 1-Q(M).

In practice, if $QM > 0{,}5$, then the most likely sex is male, and if $QM < 0{,}5$, then most likely sex is female. The more QM is close to 1, the higher the chance person is male 85% (table 3).

Table 3. Percentage of Prediction Sex Determination Using Logistic Regression

Classification Table[a]

	Observed		Predicted		
			Sex		Percentage Correct
			Male	Female	
Step 1	sex	Male	9	1	90,0
		Female	2	8	80,0

	Overall Percentage			85,0

a. The cut value is ,500

Table 4. Discriminant Functional Analysis of Right Height and Left Height

Classification Results[a,c]

		Sex	Predicted Group Membership		Total
			Male	Female	
Original	Count	Male	8	2	10
		Female	3	7	10
	%	Male	80,0	20,0	100,0
		Female	30,0	70,0	100,0
Cross-validated[b]	Count	Male	8	2	10
		Female	3	7	10
	%	Male	80,0	20,0	100,0
		Female	30,0	70,0	100,0

a. 75,0% of original grouped cases correctly classified.

Table 4. and table 5 shows the accusation of both parameters is 75%. It means the parameters have correctly classified predation gender use and width of the maxillary sinus 75% in the group. However, in the present table 6 and table 7. Showed the total percentage is 80% of both parameters using depth and volume of the maxillary sinus. The positions have significant results using all parameters for sex determination.

Table 5. Discriminant Functional Analysis of Right Width and Left Width

Classification Results[a,c]

		Sex	Predicted Group Membership		Total
			Male	Female	
Original	Count	Male	8	2	10
		Female	1	9	10
	%	Male	80,0	20,0	100,0
		Female	10,0	90,0	100,0
Cross-validated[b]	Count	Male	6	4	10
		Female	1	9	10
	%	Male	60,0	40,0	100,0
		Female	10,0	90,0	100,0

a. 85,0% of original grouped cases correctly classified.

Table 6. Discriminant Functional Analysis of Right Depth and Left Depth

Classification Results[a,c]

		sex	Predicted Group Membership		Total
			Male	Female	
Original	Count	Male	8	2	10
		Female	2	8	10
	%	Male	80,0	20,0	100,0
		Female	20,0	80,0	100,0
Cross-validated[b]	Count	Male	8	2	10
		Female	2	8	10
	%	Male	80,0	20,0	100,0
		Female	20,0	80,0	100,0

a. 80,0% of original grouped cases correctly classified.

Table 7. Discriminant Functional Analysis of Right Maxillary Sinus Volume and Left Maxillary Sinus Volume

Classification Results[a,c]

		Sex	Predicted Group Membership		Total
			Male	Female	
Original	Count	Male	8	2	10
		Female	2	8	10
	%	Male	80,0	20,0	100,0
		Female	20,0	80,0	100,0
Cross-validated[b]	Count	Male	8	2	10
		Female	2	8	10
	%	Male	80,0	20,0	100,0
		Female	20,0	80,0	100,0

a. 80,0% of original grouped cases correctly classified.

The final result showed that the potential of the maxillary sinus use four parameter (are SI right, MSV right, AP left and MSV Left as well as use similar parameter in Logistic Regression) in identifying gender was 80% in males and 80% in females, with an overall accuracy of 80%, as shown in Table 8.

Table 8. Accuracy of the Final Model in Determining Gender for the Maxillary Sinus

Actual gender	Prediction membership		Total	percentage of correctly classified gender (%)
	Male	Female		
Male	8	2	10	80%
Female	2	8	10	
total	10	10	20	

3.2 Discussion

Sex determination is an important in forensic odontology and the procedure quite unique to the postmortem (Yasar et al, 2017: Sathawane et al, 2020). Some cases using postmortem profile data in indonesia, like natural disasters and man-made disasters. For example, in landslides, volcanoes, earthquakes, tsunamis, etc. and major epidemic diseases and aircraft crashes, sports disasters, fires and shipwrecks (Idris, 2012). The goal standard postmortem dental radiographs is to obtain images that show all anatomical coverage, so that documentation of the teeth and jaws is unambiguous (Yunus et al, 2019). Given the maxillary sinus complex structure, magnetic resonance imaging (MRI) and computed tomography (CT) are the gold standards for depicting the anatomy of whitmore's tantrum. However, its use is limited due to the high radiation, high costs and limited accessibility. This drawback was overcome by the introduction of cone-beam computed tomography (CBCT) (Saccucci et al, 2015). Because cbct scans use in indonesia is not so widespread for forensic aspects, this study is one of the first pilot studies of research conducted in Indonesia to determine the gender of the maxillary sinus using CBCT scan. In this study of sex determination use, maxillary sinus can be performed 80% of discriminant functional analysis, and 85% of binary logistic

Uthman et al (2012) Gender estimation using the entire skeleton can yield an accuracy of 100% whereas pelvis and the skull can contribute of 98% accuracy (Soman, 2019; Uthman et al, 2011). In addition to displaying anatomical proximity to dental structures and having the largest volume among the paranasal sinuses, the maxillary sinus is of great importance because of its contribution to the development of facial morphology and its susceptibility to infections. Also, it is important in forensic medicine (Gulec et al, 2020).

In this study, bilateral MSVs of male and female individuals of varying ages were calculated and differences between the individuals were examined. The results show that MSVs parameters have the same percentage values between males and females of 80%.

This is in accordance with research conducted by Muthukumaravel and Manjunath (2019), showing MSV results in males and women have the same percentage value of 95% (Tambawala et al, 2016; Muthukumaravel et al, 2016). Several studies found differences in MSV values between genders and it was stated that MSV values of males are common (Gulec et al, 2020). Sharma (2014) shows that 65.16% of males and 68.9% of females were sexed correctly and the overall percentage for seeing maxillary sinuses correctly was 67.03% (Jehan et al, 2014). Uthman (2011), the result is maxillary sinus height was the good parameter that could be used to study sexual dimorphism with an overall accuracy of 71.6%. Multivariate analysis showed 74.4% of male sinuses and 73.3% of female sinuses were sexed correctly. The overall percentage is 73.9% (Uthman et al, 2011). However, several studies have shown that the combination of three maxillary sinus regions is used for sex determination of the human skull (Ibrahim et al, 2017).

V. Conclusion

The maxillary sinus measurements are valuable parameters for sex determination in forensic odontology, with a relatively good accuracy rate. The present study suggests that the CBCT measurement of Maxillary Sinus can be used as supplementary tool for gender determination in forensic odontology, however, to represent the more accuracy of sex determination using maxillary sinus in Indonesian population, suggest to do with larger sample.

Abbreviations
CBCT: Cone beam computed tomography, MSV: Maxillary sinus volume, MRI: Magnetic resonance imaging, CT: Computed tomography.

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