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A Comparative Analysis of Frontal, Maxillary Sinus and Pyriform Aperture as Gender Identification Tool Using Radiographic Morphometric Parameters

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Article History	Abstract
	***Aim**: The study was done with the aim to check for the reliability of morphometric parameters of frontal and maxillary sinuses along with pyriform aperture for sexual dimorphism on posteroanterior skull radiograph in young adults. **Material and method**: 30 individuals with equal distribution of females and males were selected considering inclusion and exclusion criteria and PA skull view of same were analyzed for frontal sinus, maxillary sinus and pyriform aperture parameters using Carestream Dental imaging software 6.14.7 CS 3D. **Statistics and Result:** Statistical analysis establishes frontal and maxillary sinus parameters in comparison to pyriform aperture parameters as reliable tool for gender assessment.*

1. Introduction

Human identification is the prime aspect of forensic science. Human skull plays a major role in human identification as it contains various gender-based features which an contribute for forensic importance (1). Based on these specific features researchers have conducted and established various parameters of identification through numerous methods such as, cheiloscopy, various tooth index, mandibular morphological characteristics and paranasal sinuses morphometry are of prime importance.

Anatomical uniqueness of frontal sinus was first studied and established by Schuller in 1921 (2). Since then, several aspects of facial sinuses have been studied by researcher for establishing the human identification status in varied population of world. Similarly maxillary sinus which is the first paranasal sinus to complete its development (3) also serves the purpose for victim identification as it remains intact even when skull is badly mutilated. So, frontal and maxillary sinuses have been established as a tool for human identification in various races of human.

Radiographs can serve as retrospective tool for identification of deceased as these are stored form of medical data which can be utilized during the process of forensic credentials. Radiographic data is generally used to confirm identification of human remains that are highly decomposed, incinerated or mutilated. Several structures like sella turcica, mastoid air cells, paranasal sinuses and particularly the frontal sinuses have been utilized for this purpose due to its irregular shape and unique nature with respect to every individual just like finger prints.

Similarly, pyriform aperture has been established dimorphic section of bone by Krogmann and Iscan in 1986 (4). Sexual dimorphic characteristics of pyriform aperture have been established in various human races. The sexual dimorphism in the size of the pyriform aperture can be influenced by racial issues, especially in populations where there is miscegenation.

So, the current study was conducted to comparatively evaluate the radiographic morphometric characteristics of frontal sinus, maxillary sinus and pyriform aperture in western Maharashtra population, which is one of its kind as literature search has not put forward any conducted comparative study on these parameters for this population.

2. Materials And Methods

After obtaining institutional ethical clearance which is in accordance with Helsinki Declaration present study was conducted in an institutional setup on western Maharashtra population. 30 random samples were selected including 15 males and 15 females. Samples were selected keeping in consideration inclusion criteria of age between 20 -45 years, considering the stable period between growth and regressive geriatric changes. Also, it is an established fact that maxillary sinus continues to pneumatize into the developing alveolar ridge as the permanent teeth erupt. At the age of 20, with the completion of the eruption, the pneumatization of the sinus ends, and it continues after the exfoliation of the teeth. (5) Hence, we excluded the patients with edentulous ridge at any age. Also, sample with no history of traumatic episode, developmental faults or medical conditions involving head and neck region were included. Written informed consent was obtained from each subject after explaining the purpose and method of the study and confirming the age by aid of supportive official document a proper case history was recorded on a prescribed format.

In the present study, Posterior anterior (PA) Skull view of patient was recorded in Kodak 9000 Digital Panoramic and Cephalometric system at standard exposure parameters (80 kVp, 10 mA, and 13.9 s), and under adequate radiation protection measures by single operator. PA view was used for analysis as image of sinuses could be obtained unmagnified and reproducible for each patient without operator's error for adjusting patient at angle for paranasal sinus view (PNS). The position of patient's head was standardized according to manufacturer's instructions. All radiographs were assessed so that only high-quality and correctly positioned radiographs were included for the study. Carestream Dental imaging software 6.14.7 CS 3D was used and the images were analysed through same.

Following metrics were assessed for: (Figure 1)

FRONTAL SINUS right and left frontal sinus was measured for
- Length – right (Rt length FS) and left side (Lf width FS) (largest dimension)
- Width – right (Rt width FS) and left side (Lf length FS) (largest dimension)
- Area – right (Rt area FS) and left side (Lf area FS) (Length X Width)

MAXILLARY SINUS right and left maxillary sinus was measured for
- Length – right (Rt length MXS) and left side (largest dimension)
- Width – right (Rt width MXS) and left side (largest dimension)
- Area (Length X Width) – right (Rt area MXS) and left side (Lf area MXS)

PYRIFORM APERTURE right and left pyriform aperture was measured for
- Length (largest dimension) (Length pYfa)
- Width (largest dimension) (width pYfa)

The reliability and reproducibility of these measurements were assessed twice by investigator within one-month interval, where the data of first session was masked at the second session to avoid bias. By this method, a general consensus was reached. The obtained measurements which showed no statistically significant differences were considered for study

3. Results and Discussion

A The obtained metrics was compiled on a MS Office Excel Sheet (v 2019, Microsoft Redmond Campus, Redmond, Washington, United States). Data was subjected to statistical analysis using Statistical package for social sciences (SPSS v 26.0, IBM). All the measured parameters data was then

subjected to discriminative statistical analysis and analysed using unpaired t-test. Statistical analysis was done by calculating the mean and standard deviation of all above mentioned parameters.

Table 1: **Inter group comparison of values**

	Sex	N	Mean (mm)	Std. Deviation	Std. Error Mean	T value	p value of t test
Age(years)	M	15	34.93	8.565	2.211	1.857	.074#
	F	15	29.53	7.318	1.889		
Rt width FS	M	15	26.427	5.6383	1.4558	.949	.350#
	F	15	24.120	7.5325	1.9449		
Rt length FS	M	15	24.1600	5.39442	1.39283	.694	.493#
	F	15	22.7600	5.65203	1.45935		
Rt area FS	M	15	660.30	247.437	63.888	1.021	.316#
	F	15	571.76	226.941	58.596		
Lf width FS	M	15	31.440	7.1234	1.8392	2.406	.023*
	F	15	25.933	5.2756	1.3622		
Lf length FS	M	15	27.287	7.5820	1.9577	1.521	.140#
	F	15	23.967	3.7445	.9668		
Lf area FS	M	15	891.7253	366.55532	94.64418	2.427	.022*
	F	15	631.0900	196.50437	50.73721		
Rt width MXS	M	15	26.933	5.6558	1.4603	2.015	.054#
	F	15	23.167	4.5201	1.1671		
Rt length MXS	M	15	27.85	3.934	1.016	1.358	.185#
	F	15	25.87	4.077	1.053		
Rt area MXS	M	15	761.799	242.1429	62.5210	2.112	.044*
	F	15	603.931	158.6642	40.9669		
Lf width MXS	M	15	26.067	5.2139	1.3462	1.417	.167#
	F	15	23.513	4.6383	1.1976		
Lf length MXS	M	15	28.360	4.4912	1.1596	1.812	.081#
	F	15	25.727	3.3904	.8754		
Lf area MXS	M	15	752.2820	235.33631	60.76357	2.056	.049*
	F	15	606.2733	142.46331	36.78387		
Length pYfa	M	15	43.513	4.4659	1.1531	.685	.499#
	F	15	42.380	4.5943	1.1862		
width pYfa	M	15	28.527	2.5725	.6642	1.199	.241#
	F	15	26.600	5.6672	1.4633		

All the mentioned metric parameters were having higher mean values for males as compared to female subjects but statistically significance difference between the groups ($p<0.05$) was present only for, (Table 1).

- Left width of Frontal Sinus,
- Left area of Frontal sinus
- Right area Maxillary Sinus
- Left area Maxillary sinus

Human identification in forensics is through a series of methods, among them finger prints been most widely adopted but in cases when soft tissue is preserved. However, when body is incinerated or is in skeletal form, forensic dental and anthropologic analysis becomes the necessity for identification. Radiographs of an individual may serve as a retrospective tool for identifying corpses that are deemed unrecognizable. (6). Radiographs play an important role in human identification and establishing the gender of deceased, which is known to be the first and foremost important step for human

identification. Radiographic details in form of retrospective data can serve as important tool for establishing one's identity. Present study was conducted to comparative assessment of frontal sinus, maxillary sinus and pyriform aperture for the determining gender of an individual. No such comparative assessment has been done before for same purpose. Various studies have been done to look for diagnostic accuracy individually for frontal, maxillary sinus and pyriform aperture. Hence no comparative data is available in literature for same. Present study establishes that pyriform aperture shows no statistically significant sexual dimorphism in age group of 20 to 45 years which is not in accordance to various anthropometric studies done on human skull (7) which has established dimorphic characteristics of pyriform aperture. Present study establishes mean length of pyriform aperture (Length pYfa) for males as 43.5mm were as for females as 42.5mm i.e., higher for males. Similarly mean width of aperture (width pYfa) was calculated to be 28.5mm for males and 26.6mm for females, i.e., higher for males. But both these values prove to be statistically insignificant for gender determination which was in accordance to study conducted by DE ARAÚJO et al (8) in 2018 on human skull of Brazilian population. Similar study done by Moreddu E et al (9) on CT image of French population establishes gender diversity within a wide age group of 15 – 97 years. Another anthropological study done on North Indian human skull of unknown age and gender by Adil Asghar et al (7) establishes pyriform Length and width as statistically significant parameter for sexual dimorphism. Other study done on south Indian skull (10) establishes pyriform aperture height as statistically significant parameter for gender establishment.

Frontal sinus in present study was studied for length, width and area of sinus separately for right and left side out of which left width and left area of frontal sinus establishes a statistically significant difference between males and females. Mean values of length, width and area on right side came to be 24.2mm, 26.4 mm and 660.3 mm^2 for males and 22.7mm, 24.1mm and 571.7mm^2 for females. Similarly on left side mean length, width and area for males was 27.3mm, 31.4mm and 891.7 mm^2 and for females it was 23.9mm, 25.9mm and 631.1 mm^2. Similar study done on PA view for frontal sinus by Belaldavar *et al. (*2), done on Indian origin population of age 25- 30 years, establishes all these above mentioned parameters significant for establishing gender. Present study draws a similar conclusion of higher parameters of left frontal sinus in both males and females, which was also concluded by Schuller in (1943), Dr. Uppe, Anu Netharaa et al. and Vrushali P Karadkhelkar (1,11)

Similarly, Maxillary sinus parameters in present study show significant values for gender determination. All the studied parameters were higher in males compared to females, these results were consistent with similar studies done by Deshpande et al (5) on western Maharashtra population and Kandel S, et al (12).

4. Conclusion

Present study reestablishes that sinuses are gender specific and are predictable parameters of forensic importance. However, pyriform aperture is an established parameter for gender determination in several anthropological studies but this study could not generate the same. Also, very fewer studies have been conducted on radiographs to establish pyriform aperture as identification tool. However present study was done on a limited sample size, so greater sample strength may draw a different conclusion. Present study however reestablishes frontal and maxillary sinus parameters as more powerful tool for gender identification in comparison to pyriform aperture.

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