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Gender Determination Using Frontal Sinus Index on Lateral Cephalograms – A Retrospective Observational Study

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Abstract

Determination of gender from unidentified human skeletons has a vital role in medico-legal investigations. The morphology of frontal sinus is unique to person and can be used in personal identification effectively. Sinus radiographs are useful in sex assessment of an individual. The aim and objectives of the present study were to determine gender using frontal sinus index from lateral cephalograms and also to evaluate the reliability of this technique. Methodology: A total of 100 digital lateral cephalograms (50 males and 50 females) were obtained from previous data of patients with age ranging between 20 – 50 years. The width, height and frontal sinus index were calculated and discriminant equation was derived using discriminant function analysis to determine gender. Results: The mean frontal sinus height and width were greater among males than females. The frontal sinus index was greater among females than males. The accuracy of frontal sinus measurements to identify females was 74.0% and males was 84.0% using discriminant function analysis of frontal sinus. Conclusion: The morphometric analysis of frontal sinus can be used as an adjunctive method for gender determination.

Keywords: Frontal sinus index, Lateral cephalograms, Personal identification, Discriminant function equation, Personal identification

Introduction

The assessment of correct gender from an unidentified skeletal remains is an important aspect of forensic science especially in cases of mass disasters and criminal investigations(1,2).Radiological examination of sinus is the most commonly used and accepted technique in the identification of highly decomposed, cremated, or disfigured human remains and it plays a pivotal role in

personal identification (2,3) . The fundamental importance of anthropometric characteristics of skull is an integral part in the identification of an individual (2).

Frontal sinus is a cavity filled with air, located in the frontal bone and originates from the ethmoidal cells embryonically. It begins to develop during 4th or 5th week of intrauterine life (2). Frontal sinus is absent or insignificant at birth (4). It is formed by two chambers, typically asymmetrical which are separated by a bony septum (5). The asymmetry of two chambers is due to the independent development of each sinus (6). At 2 years of age, the sinus starts grow in a vertical direction and is visible on radiographs at the age of 8 years (4). It continues to grow until puberty and tends to stabilize and reach to maximum size at the age of 20 years. As it is not same in any two individuals and it is one of the most unique feature that helps in the personal identification as that of finger prints. Due to the intact nature of the frontal sinus it can be used as an adjunctive method in determination of gender (6).

Lateral cephalograms can be used in the identification of sex as it is readily available and simple (7) and doesn't require any expertise (6). It is also used due to its reliability and cost effectiveness (2). The frontal sinus can be clearly visible on lateral cephalograms (1). The following study was designed to derive an equation for gender determination using frontal sinus index on lateral cephalograms and to evaluate the reliability of the technique and discriminant function analysis.

Materials and Methods

The present retrospective cross-sectional study was conducted at Sri Sai College of Dental Surgery, Vikarabad, Telangana in the Department of oral medicine and radiology. A total of 100 cephalograms were obtained from the previous data of patients with age group ranging between 20 - 50 years, and consisting of 50 females and 50 males, and frontal sinus index was calculated for each one of the radiograph.

Inclusion Criteria

Digital lateral cephalograms with good quality of 50 female patients and 50 male patients ranging between ages of 20 – 50 years with no artifacts were included.

Exclusion Criteria

Lateral cephalograms of patients who are less than 20 years and greater than 70 years were excluded. Bilateral or unilateral lack of the frontal sinus, any frontal sinus inflammation, frontal sinus tumor, abnormally enlarged frontal sinus, fracture of sinus, facial trauma, frontal sinus pathology, excessive artifacts and frontal image is unclear in the lateral cephalograms were excluded.

Methodology

The sinus analyses were interpreted on all the radiographs using Care Stream Dental Imaging software. The frontal sinus height, width were evaluated by a qualified radiologist on all lateral cephalograms. The Frontal Sinus Height (F-H) was measured by joining the most superior to most inferior point. The Frontal Sinus Width (F-W) was measured by drawing a line perpendicular to line FH at its deepest portion. The ratio of maximum height to width was calculated as Frontal sinus index (FSI). All measured values of frontal sinus height, width and FSI were analyzed using IBM.SPSS Statistics Software 23.0 Version.

Statistical Analysis

The mean values of frontal sinus height, frontal sinus width and frontal sinus index (FSI) among females and males, were obtained using unpaired t test. For determination of gender, discriminant function analysis and discriminant equation was derived with gender as classifying variable and FSI as an independent variable. Depending on the discriminant scores (D) obtained the gender determination was recorded accordingly with

probability value 0.05 considered as significant level in above both statistical tools.

Results

The mean age of males was 30.40 and females was 25.68 in the present study which consists of lateral cephalograms of 50 males and 50 females.

Frontal Sinus Height (F-H)

The maximum frontal sinus height for males was 31.15 and for females was 28.95 and the minimum frontal sinus height for males was 21.01 and for females was 20.63. The mean value for F-H recorded for males was 26.08 and for females was 24.79 (Fig 1).On statistical analysis, the frontal sinus height was greater among males than females with statistically non-significant with p values 0.165 (Table 1).

Frontal Sinus Width (F-W):

The maximum frontal sinus width for males was 12.59 and for females was 8.94 and the minimum frontal sinus width for males was 8.17 and for females was 5.96. The mean value for F-W recorded for males was 10.38 and for females was 7.45 (Fig 2). On statistical analysis, the frontal sinus width was greater among males than females with statistically highly significant p value of 0.0005 (Table 1).

Frontal Sinus Index (FSI):

The ratio of frontal sinus height to frontal sinus width is taken as Frontal Sinus Index (FSI). The maximum FSI for males was 2.98 and for females was 4.01 and the minimum FSI for males was 2.14 and for females was 2.79 (Fig 3).The mean value for the FSI recorded for males was 2.56 and for females was 3.40. On statistical analysis, the FSI was greater among females than males with statistically highly significant p value of 0.0005(Table 1).

The lowest value was presented by frontal sinus width (MW) which is comparatively the better indicator for sex determination among all the variables, in the present study. The Discriminant Equation for frontal sinus index (FSI) is as follows: D = 1.91 X FSI - 5.685. By substituting the specific values in this equation it is helpful to calculate the D values for gender determination. It indicates males if the calculated D value is closer to -0.802 whereas it indicates females if D value is closer to +0.802. To the present study sample determinant equations were applied, with a total accuracy of 79.0 % in gender determination and 74.0 % females and 84.0 % males were correctly evaluated.

Discussion

The crucial part of forensic medicine is sex determination of unidentified corpses in mass disasters, road traffic accidents, fire accidents and investigations of crimes (2). The forensic dental and anthropologic analyses were useful to identify the individual when a body is burnt (8) and anthropologic methods came into existence when the soft tissues of humans are putrid and severely damaged DNA is present. It will be difficult to identify an individual using DNA or finger print analyses (6).In case of human identification the radiographic images can be used in identifying corpses that are unrecognizable (9). The skull is an important indicator for sexual dimorphism secondary to the pelvis (2). The skeleton can be used for identification which can resist both natural and unnatural abuse and violence (6). Paranasal sinuses can be used as one of the most important procedure in identifying a person (2).

The importance of the frontal sinus for sex determination was given by Schuller (6). Lateral cephalograms were used in assessment of morphometric measurements of paranasal sinuses (10). In the present study, the mean values of height and width of frontal sinus were significantly greater in males than females whereas the mean value of frontal sinus index (FSI) was greater among

females when compared to males. Discriminant function analysis (D) was done for gender prediction and the discriminant equation was also derived using gender as classifying variable and FSI as an independent variable. It indicates males if the calculated D value is closer to -0.802 and females if the calculated D value is closer to +0.802. To the present study these equations were applied and revealed a total accuracy of 79.0% in gender determination with 74.0% and 84.0% females and males were correctly identified respectively.

Camargo et al. in 2007 conducted a study on 100 radiographs taken by the Caldwell technique between 20 and 30 years old using the width and height of frontal sinus, showed that the mean values of the frontal sinus were greater among males. They also showed a tendency for the left sinus area was larger than the right sinus area. The accuracy rate in gender determination was 79.7% (11). In a study conducted by Zhang et al. 2011 showed the morphometric measurements of frontal sinus was highly variable from individual to individual. Also concluded that frontal sinus would be a better tool in personal identification rather than in gender determination (12). Another study was conducted by Mathur et al. in 2013, showed the width and height of frontal sinus was significantly larger among males than that of females. They concluded that the frontal sinus could be used as an adjunctive method for sex determination (13).

Belaldavar et al. in 2014 conducted a study on 300 radiographs of frontal sinus which showed the mean values of the frontal sinus height, width and area of males sinuses were statistically significant to that of female sinuses. The accuracy in determination of sex was 64.6% using logistic regression analysis (8). Another study conducted by Sai kiran et al. in 2014, using digital lateral cephalograms, showed that the mean values of height and width of frontal sinus were significantly higher in males when compared to females and frontal sinus index was calculated using discriminant analysis. They also concluded that the frontal sinus index was statistically significant among females than that of males and can be used in gender determination. In this study, the accuracy to determine the sex was 67.6% (2).

A study conducted by Justin Michel et al. in 2015, the total volume of left and right sinuses was calculated using three-dimensional reconstruction and showed that the mean sinus volume was significantly larger among males than that of female. The accuracy in determination of sex was 72.5% (14). A study conducted on 475 digital lateral cephalograms of adult Han citizens from Xinjiang by Luo H et al. in 2017, calculated the maximum height, depth, and area of the frontal sinus. The results showed that the use of frontal sinus index and area for sex discrimination was more accurate than using the frontal sinus index alone and obtained a correct discrimination rate for all samples was 76.6% (1).

The above mentioned studies showed similar results to that of the present study in which the frontal sinus height (FH), frontal sinus width (FW) was noticed to be greater among males than females and the frontal sinus index (FSI) was greater among females than males. In the present study the males and females were identified correctly with an accuracy of 84% and 79% respectively.

Conclusion

From this study we can conclude that frontal sinus index could be used as an aid in sex determination. It is important to identify accurate gender from unidentified remains and is the foremost step in the forensic investigations. The results in the present study are reliable and reproducible and showed greater frontal sinus height and width among males than females and frontal sinus index was greater among females than males. Frontal sinus index can be used as an adjunctive tool in sexual

dimorphism. However, further studies with larger sample size are recommended to standardize the use of cephalograms and procedure of measurements.

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Table 1: Comparison between Frontal Sinus Height, Width & FSI in males and females ($p < 0.01$ is considered significant)

Parameters	Gender	N	Mean	p value
Height (F-H)	Males Females	50 50	26.08 ± 5.07 24.79 ±4.16	0.165
Width (F-W)	Males Females	50 50	10.38 ± 2.21 7.45 ± 1.49	0.0005
Frontal Sinus Index (F.S.I)	Males Females	50 50	2.56 ± 0.42 3.40 ± 0.61	0.0005

Fig 1: Comparison of mean values of Frontal Sinus Height in males and females

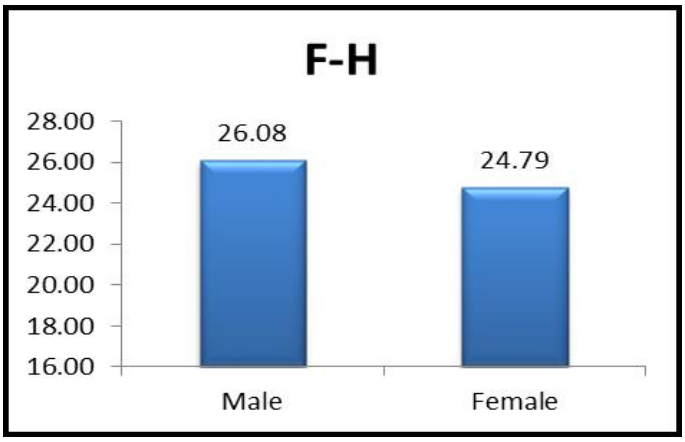

Fig 2: Comparison of mean values of Frontal Sinus Width in males and females

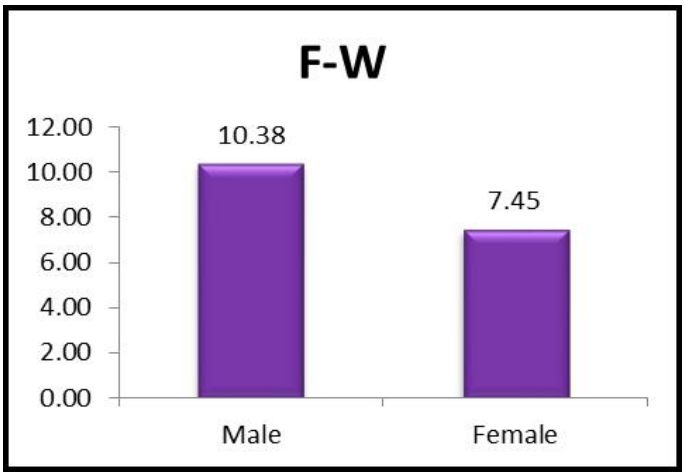

Fig 3: Comparison of mean values of Frontal Sinus Index in males and female