Predictability of Sex from Frontal Sinus in Nepalese Population

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ABSTRACT

Background
Various methods had been used for personal identification. Scientific basis of identification was initiated and progressed after 19th century which may be attributed to various scientists. With the invention of X-ray the field of identification further progressed. Modern radiological diagnostic equipments have greatly assisted in the field of forensic. Frontal sinuses are paired lobulated air cavities located posterior to superciliary arches in the frontal bone. Computed Tomography is best used to study frontal sinuses.

Objective
To evaluate bilateral Frontal sinus for sexual dimorphism using Computed Tomography.

Method
Anterior posterior length, transverse width and height of the bilateral Frontal sinus were directly measured on CT DICOM image, using Electronic Caliper in DICOM viewer software. A total 100 CT scans, 50 of each sex were collected was analysed using SPSS-20 in present study.

Result
The mean age distribution for male is 34.74±8.66, and for females 35.34±8.88. The mean of all the measurements take was larger in males in comparison to females with p < 0.00. The paired t test showed left side is larger than right. The discriminant function showed high significance for each measurement and also when all the measurements were combined.

Conclusion
Though the study being unique for Nepalese population, caution should be taken when frontal sinus is used as the only parameter. However in combination with other morphometric data is advised.

KEY WORDS
Computed tomography, Frontal sinus, Identification, Lobulated air cavities, Sexual dimorphism, Superciliary arches
INTRODUCTION

Historically, various methods had been used for personal identification, relying on one's memory in order to identify based on appearance and voice was the most common methodology applied. After 19th century scientific based forensic identification was initiated and progressed. Today's advancement in the field of identification can be attributed to many scientists, Johannes Evangelist Purkinje for documentation of finger print followed by Sir Francis Galton who later classified fingerprint, which is used till date for identification. Similarly Alphonse Bertillon gave the 1st scientific method for identifying criminals based on measurement of anthropological features. In 1895 the discovery of Rontgen rays by Wilhelm Conrad Rontgen became the foundation stone for the rapid development of Medical science and Forensic identification. On the way there were many important discovery, ABO blood grouping, Rhesus blood grouping and then came DNA fingerprinting, thus making forensic identification a scientific and skillful art.

First recorded use of radiology in forensic was in 1896 by Prof. Arthur Schuster, since then the field of radiology has made tremendous advancement like USG, CT, MRI, and MSCT. Use of these advances in forensic has also increased. The proposal of Schuller from Vienna in 1921, suggesting use of radiological study of Frontal sinus got us interested, thus we aimed this study to study frontal sinus for prediction of sex in the Nepalese population.

Frontal sinuses are paired lobulated air cavities located posterior to superciliary arches in the frontal bone, each of this frontal sinus opens into the corresponding middle meatus via the infundibulum. Frontal sinuses are not completely developed by 20 years. Anthropological study has an element of being population specific, have no such study in Nepalese population further encouraged us to initiate this study.

METHODS

Following the ethical standard set by declaration of Helsinki, we submitted the proposal to Institutional Review committee of Kathmandu University School of Medical Sciences, Dhusikhel, Nepal for approval. On receiving clearance from IRC, we initiated this cross sectional hospital based study in the aforementioned institute. The study constitutes of 100 CT scan images of individual above the age of 20 years, between the periods May 2018 to August 2018. Of the 100 individual included in this study, verbal consent was obtained from the patent/patent party for the data to be collected with assurance that their identity will be protected. In this study we included randomly selected patents, needed CT scan for diagnostic purpose during the course of their treatment.

RESULTS

The study aiming to observe sexual dimorphism in Nepalese population was conducted by the Department of Forensic Medicine in collaboration with Department of Radiology in Kathmandu University School of Medical Sciences, constitute of total of 100 3D CT head images belonging to 50 male and 50 female. For males the age distribution ranges from 22 years to 48 years with mean 34.74±8.66 and for female ranges from 22 years to 49 years with mean 35.34±8.88 detailed in table 1.

**Table 1. Age distribution of the sample**

| Gender | N  | Minimum | Maximum | Mean   | Std. Deviation |
|--------|----|---------|---------|--------|----------------|
| Males  | 50 | 22      | 48      | 34.74  | 8.366          |
| Females| 50 | 22      | 49      | 35.34  | 8.888          |
The data thus collected showed that of the 100 study samples, 6 cases showed bilateral absence of frontal sinus of which 3 belonged to male and 3 to female. Unilateral absence of frontal sinus was noted in 4 cases of which 3 belonged to female (Right 2; Left 1), 1 to male (Right). The data was analyzed using Descriptive analysis, detailed in table 2, stating males have larger frontal sinus in comparison to female and also that the left side of frontal sinus were larger than the right. In males the mean value for height of frontal sinus were 1.68±0.66 and 1.81±0.83, for Anterior posterior length were 0.98±0.28 and 1.04±0.23, for Transverse width were 1.90±0.67 and 2.11±0.82 and for volume calculated were 1.86±1.41 and 2.44±2.11 of right the left respectively. In females mean for height were 1.20±0.58 and 1.23±0.48, for Anterior posterior length were 0.76±0.18 and 0.79±0.29, for Transverse width were 1.20±0.58 and 1.66±0.57 and for volume calculated were 0.79±0.96 and 1.02±0.83 for right and left respectively.

The observation made from the descriptive analysis suggested that the data be subjected to student t test and paired t test. Student t test showed high significant (p < 0.000) difference between male and female but the paired t test showed no significant difference between right and left side except for right and left transverse width in females, expressed in table 2 and table 3.

Student t test showing a high significance (p < 0.000) difference, the data collected and volume calculated was further analysed using discriminant function analysis. Since the paired t test showed no significance difference, the right and left side were in combination entered in SPSS for discriminant function analysis to contemplate weather a single dimension measured of frontal sinus irrespective of side has a effect of significance and predictability.
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Discriminant function analysis for each of the dimension measured showed very promising result with high significance. Eigen value for height was 0.211, for Anterior Posterior Length was 0.270, for Transverse Width was 0.346 and for volume calculated was 0.273. Canonical Correlation for height was 0.418, for Anterior Posterior Length was 0.461, for Transverse Width was 0.507 and for volume calculated was 0.463. Wilks Lambda and Chi-square were 0.826 and 16.667, for Anterior Posterior Length were 0.787 and 20.795, for Transverse Width were 0.743 and 25.824, and for volume calculated were 0.786 and 20.973 respectively. All the measurements showed very high significance has p value 0.000, depicted in table 4.

All the measurements taken from frontal sinus and the volume calculated, stepwise discriminant function analysis was developed (table 5). The stepwise discriminant function analysis also showed high significance (p < 0.000) with Eigen value 0.540, canonical correlation 0.592, Wilk’s Lambda 0.649 and chi-square 36.270.

Eighty percent of the original group was correctly classified between male and female when all the variables of frontal sinus and volume calculated were used. When single variable was used, Height showed 65.6%, APL showed 73.3%, TD showed 76.7% and the volume showed 70.0% predictability.

### DISCUSSION

In 1895 Zukerkandl, described the uniqueness of frontal sinus which was confirmed by Christensen.\(^6\) Seventy-four monozygotic and dizygotic twins were examined by Asherson for uniqueness of frontal sinus, stated frontal sinus were unique even in twins.\(^7\) Due to the anatomical location of frontal sinus, it is well preserved in decomposed and/or skeletonized human remains, and remains stable after 20 years of age until old age when pneumatisation may occur owing to atrophic changes.\(^8\) The age group of our study was 20 to 50 years, acknowledging that development of frontal sinus is completed by 20 years of age. Modification in frontal sinus has been documented in tumors, trauma, infection and environmental factors. Applying radiographic image of frontal sinus for identification was suggested by Suhuller, later Culbert and Law described the complete process using pneumatic space. In this study, we studied frontal sinus for sex prediction rather than uniqueness of it.\(^9\)–\(^11\)
In our study, bilateral absence of frontal sinus was observed in 6% (6% in both sexes), and unilateral absence was seen in 4% of the total sample, of which 6% (4% and 2% in right and left sided respectively) were found in female and 2% in males which was right sided. Absence of frontal sinus was noted in various studies, but percentages differ, 33% bilateral and 12.6% unilateral absence of frontal sinus was noted in Chinese Han population.11 The Turkish population stated 3.8% bilateral and 0.8% unilateral absence, similarly 10% bilateral and 2% unilateral absence was observed in Northern Ireland population.13,14 Presence of metopic suture is always associated with absence of frontal sinus, was emphasized by Schuller.15 The difference in absence of frontal sinus both bilateral and unilateral may be attributed to the definition of absence of frontal sinus given by Szilvassy or that there exist a differences on the grounds of environmental as well as genetic factor.16 Morphology of frontal sinus is affected by growth hormone (somatotropin).

The point where most of the studies on frontal sinus consistently converge, including our study, is that males have larger frontal sinus as compared to that of female.13,14,16-19 The difference may be attributed to the genetic, hormonal factor and gonadal steroids which affect the response of growth hormone.17 Our study show that left side of frontal sinus were slightly larger than the right side but studies by Belaldavar et al., Camargo et al. and Ponde et al. showed larger right side of frontal sinus.18-20 Due to independent development of frontal sinus, the difference was observed, where in it is commonly witnessed that one frontal sinus is larger than the other and sometime it may overlap after crossing the midline, which may be due to unequal resorption of the dipole during sinus development.13,21

Student t test showed a significant (p < 0.000) difference between male and female in all the measurements and volume calculated were taken in our study. The paired t test showed no significant difference between right and left side of frontal sinus in both the sexes. The predictability was as high as 80% when all the measurements of frontal sinus and volume calculated was used. However when individual parameters of frontal sinus, were taken height of frontal sinus showed 65.6% predictability, Volume calculated showed 70%, Anterior posterior length 73.3% and Transverse width showed 76.7% predictability.

In a study conducted by Camargo et al in Brazilian population demonstrated 79.7% accuracy to predict sex with left area better suited for sex determination.10 Uthman et al. in a study conducted in Iraqi population demonstrated an accuracy of 76.9%.22 Our study demonstrated 80% accuracy when all the measurements of right and left side of frontal sinus were combined. In respect to the modalities our study, is similar to that of Uthman et al. they also conducted their study on CT.23 A much recent study conducted on Indian population by Belaldavar et al. had the accuracy of 65.5%, though our predictability were highest, the difference may be attributed to population, genetics and the environment.18

CONCLUSION
Frontal sinus in forensic for its uniqueness has been the focus of various authors, our study instead focused on sex prediction and the results (80% accuracy) in Nepalese population is promising. However much studies needs to reckon with larger sample from different population in Nepal to determine the accuracy. Using only frontal sinus for sex determination should be cautioned, however in combination with other morphometric may be advised.

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