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Original Research Article

# Sexual Dimorphism of Frontal and Maxillary Sinus, A Computed Tomographic Study in Bidar District Karnataka

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**Abstract:**

Radiography is used in forensic pathology for identification of humans in cases where body is decomposed, fragmented or burned. It has been studied that paranasal sinuses are used for postmortem identification in forensic medicine because they can remain intact even in incinerated victims. Computed tomography (CT) scan are excellent imaging modality to evaluate paranasal sinuses, it provides detailed information that are not available from radiographs.

Morphometric knowledge about the paranasal sinuses is essential for an otolaryngologist, orthodontist and neurosurgeon to choose the most suitable surgical procedure and prevent damage to craniomaxillofacial structures. Gender determination is an important step in identification in forensic medicine; CT measurements of paranasal sinuses are useful to support gender determination. Parameters like, Width, length, height of maxillary sinus together can be used for gender determination when only skull is available.

There is very less literature to evaluate and compare maxillary and frontal sinuses for gender dimorphism using computed tomography. So, this study design to evaluate the reliability and accuracy of maxillary and frontal sinus for gender determination using CT and it application as an aid in forensic investigation for gender determination.

**Keywords:** Computed tomography, Paranasal sinuses.

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## Introduction

George Buschan- A Pioneer in dental anthropology has done various studies about the anthropometric characteristics which is of fundamental importance.[1] Many parts of the skeleton can be used for identification of a person, however the most reliable parts of the skeleton are those which are anatomically variable or which do not exhibit change due to trauma, illness or surgical intervention. [2] Matching specific features detected on the dead bodies with data recorded during the life of an individual is an important aspect in forensics, and can be performed by fingerprint analysis, deoxyribonucleic acid matching, anthropological methods, radiological methods and other techniques which can facilitate age and sex identification.[3] Determination of gender and estimation of stature from the skeleton is vital to medicolegal inquiries. Skull is composed of hard tissue and is the best-preserved part of skeleton after death, hence, in many cases it is the only available part for forensic examination. [2]

Forensic anthropology may be defined as the application of biological or physical anthropology in the service of justice. [4] Forensic personal identification is a fundamental topic of forensic sciences and technologies to identify live subjects, recently deceased bodies and human remains often at a crime scene by using several appropriate techniques [5].

Craniometric features are included among these characteristics which are closely related to forensic dentistry. [2] Sexual dimorphism refers to the systemic difference in the form (either in shape or size) between individuals of different sexes in the same species. Researchers have revealed that the shape and size of the maxillary sinus differ between males and females and in various populations. [6] It has been stated that during adulthood, their shapes and sizes change especially due to loss of teeth. After the maximum growth period, the volume of the maxillary sinus decreases in both genders. This

is explained by the fact that the loss of minerals in the bone matrix contracts the maxillary sinus and result in a decrease in the maxillary sinus volume in both genders. [7] The frontal sinus is another Craniometric feature with significance in forensic identification due to its irregular shape and because of the individual characteristics which makes the frontal bone unique for every individual, just as with finger prints even for monozygotic twins.[8] Frontal sinus has great variability and its structure does not change after the age of 18 years except for very rare occurrences as fractures, tumors or severe infections.[8] The studies on correlation of the morphology of the frontal sinus with gender showed that the frontal sinus is smaller in women, as aspect that points out its unique characteristic and importance in human identification, as well as in the determination of age.[9]

Radiography was used as forensic tool for human identification, especially in cases where the body is decomposed, fragmented, or burned (Kiruba et al., 2014).[10] Historically, the application of x-ray in forensic sciences was introduced in 1986, just one year following the x-ray discovery by Prof. Wilhelm Conrad Roentgen on November 8, 1985. It was Schuller from Vienna who proposed the possibility of utilizing radiological images of the frontal sinus for identification purposes in 1921. The first complete radiological identification by using pneumatic cells of the skull was described by Culbert & Law in 1927 (Culbert & Law, 1927; Gruber & Kameyama, 2001; Carvalho et al.,2009).[1]

## Materials and Methods

**Sources of Data:** CT images of patients age group 18-50 years, admitted for CT evaluation of head and neck region without any facial trauma, previous sinus surgeries, pathological lesions involving frontal and maxillary sinus, in brims hospital bidar Karnataka.

**Method of Collection of Data:**

**Sample Size: 150**

Sample size of 75 males and 75 females can achieve a power of 80% to detect a difference of 2mm in the maxillary sinus mediolateral dimension between the males and females with pooled standard deviation of 3.6 and with a significance level of 0.05 using a 2 sided 2 sample-tes t(1). The sample size was calculated using statulator software.

**Reference for sample size calculation:** Ulthman AT, Al-Rawi NH, Al-Naaimi AS, AI-Timmi JF. Evaluation of maxillary sinus dimensions in gender determination using helical CT scanning. Journal of forensic sciences. 2011 Mar;56(2):403-8.

**Inclusion Criteria:**

Patientsage group 18-50 years admitted for CT evaluation of head and neck region.

CT images without any artefacts.

**Exclusion Criteria:**

CT images of patients with facial trauma

CT images of patients with previous sinus surgeries

CT images of patients with pathological lesions involving frontal and maxillarysinus.

**Statistical Analysis:**

The maxillary and frontal sinus data's were transferred on Microsoft Excel 2013 software (Microsoft office Professional Plus, Microsoft Corporation, Redmond, USA). The data were analysed using SPSS version 16. The Canonical discriminant functional analysis was performed to assess whether the maxillary and frontal sinus measurements could be used for gender determination. MANOVA test was carried out to find the difference between two groups.

Multiple logistic regression was performed to generate an equation and optimum cutting score (Zc) was derived that could be reliably used to classify the observations according to gender. The paired t-test was done for comparison of the means of the dimensions measured for the two groups and p value $< 0.05$ was taken as statistically significant. ANOVA test is used to correlate the measurements of maxillary and frontal sinus with age subgroups. A two-way mixed intra-class correlation coefficient was carried out to test the degree of reliability.

## Results

The total sample composed of 150 subjects with 75 males and 75 females, among the subject's highest value was seen in 31-40 age group.

**Table 1: Distribution according to age group**

| | | Male | | Female | | Total | p |
|---|---|---|---|---|---|---|---|
| | | No | % | No | % | | |
| Age group | ≤ 20 | 9 | 12 | 11 | 14.7 | 20 | 0.18 |
| | 21-30 | 30 | 40 | 21 | 28 | 51 | |
| | 31-40 | 34 | 45.3 | 43 | 57.3 | 77 | |
| | 41-50 | 2 | 2.7 | 0 | 0 | 2 | |
| Total | | 75 | 100 | 75 | 100 | 150 | |

**Table 2: Comparison of age between males and females**

| Group | | N | Mean | Standard Deviation | t | P | Inference |
|---|---|---|---|---|---|---|---|
| Age | Male | 75 | 30.15 | 7.71 | -0.516 | 0.607 | Not |
| | Female | 75 | 30.79 | 7.49 | | (>0.05) | significant |

**Table 3: Comparison of maxillary sinus right mediolateral width between males and females**

| Group | | N | Mean | Standard Deviation | t | P | Inference |
|---|---|---|---|---|---|---|---|
| Right | Male | 75 | 22.51 | 2.82 | -3.062 | 0.003 | Highly |
| width | Female | 75 | 24.48 | 4.83 | | (<0.01) | significant |

The right mediolateral width of maxillary sinus for males was 22.51+\- 2.82when compared with females 24.48+/- 4.83, shows highly significant.

**Table 4: Comparison of maxillary sinus left mediolateral width (mm) of maxillary sinus in males and females for maxillary sinus**

| Group | | N | Mean | Standard Deviation | T | p | Inference |
|---|---|---|---|---|---|---|---|
| Left | Male | 75 | 23.84 | 4.11 | 1.512 | 0.133 | Not |
| Width | Female | 75 | 22.83 | 4.07 | | (>0.05) | significant |

The left mediolateral width for males was 23.84+\-4.11 when compared with females 22.83+/- 4.07 it shows no significance.

**Table 5: Comparison of maxillary sinus right anteroposterior length between males and females**

| Group | | N | Mean | Standard Deviation | t | p | Inference |
|---|---|---|---|---|---|---|---|
| Right | Male | 75 | 32.66 | 4.65 | -4.233 | 0.0001 | Highly |
| Length | Female | 75 | 36.00 | 5.03 | | (<0.01) | significant |

The right anteroposterior length of males is 32.66+/- when compared with females 36+/- 5.03 shows highly significant.

**Table 6: Comparison of maxillary sinus left anteroposterior length between males and females**

| Group | | N | Mean | Standard Deviation | t | P | Inference |
|---|---|---|---|---|---|---|---|
| Left | Male | 75 | 34.12 | 7.37 | 0.825 | 0.411 | Not |
| Length | Female | 75 | 33.30 | 4.44 | | (>0.05) | significant |

The left anteroposterior length of males is 34.12+/- 7.32 when compared with females 33.30+/-4.44 shows no significance.

**Table 7: Comparison of maxillary sinus right height between males and females**

| Group | | N | Mean | Standard Deviation | t | P | Inference |
|---|---|---|---|---|---|---|---|
| Right | Male | 75 | 27.81 | 4.82 | 9.034 | 0.0001 | Highly |
| Height | Female | 75 | 21.45 | 3.72 | | (<0.01) | significant |

The right height of maxillary sinus in males is 27.8+/-4.82 when compared with females 21.45+/-3.72 shows highly significant.

**Table 8: Comparison of maxillary sinus left height between males and females**

| Group | | N | Mean | Standard Deviation | t | P | Inference |
|---|---|---|---|---|---|---|---|
| Left | Male | 75 | 26.60 | 5.23 | -0.099 | 0.921 | Not |
| Height | Female | 75 | 26.67 | 4.28 | | (>0.05) | significant |

The left height for males is 26.6+/-5.32 when compared with the females 26.67+/-4.28 shows no significant.

**Table 9: Comparison of maxillary sinus right volume between males and females**

| Group | | N | Mean | Standard Deviation | t | p | Inference |
|---|---|---|---|---|---|---|---|
| Right | Male | 75 | 10.41 | 2.48 | 0.469 | 0.640 | Not |
| Volume | Female | 75 | 10.16 | 3.90 | | (>0.05) | significant |

The right maxillary sinus volume in males is 10.41+/- 2.48 when compared with females 10.16+/- 3.9 shows no significance.

**Table 10: Comparison of maxillary sinus left volume between males and females**

| Group | | N | Mean | Standard Deviation | t | p | Inference |
|---|---|---|---|---|---|---|---|
| Left | Male | 75 | 11.32 | 3.82 | 1.097 | 0.274 | Not |
| volume | Female | 75 | 10.67 | 3.50 | | (>0.05) | significant |

The maxillary sinus left volume in males is 11.32+/- 3.82 when compared with females 10.67+/- 3.5 shows no significance.

**Table 11: Comparison of maxillary sinus total distance between males and females**

| Group | | N | Mean | Standard Deviation | t | p | Inference |
|---|---|---|---|---|---|---|---|
| Total Distance | Male | 75 | 80.17 | 6.71 | 1.724 | 0.087 (>0.05) | Not significant |
| | Female | 75 | 78.29 | 6.67 | | | |

The maxillary sinus total distance in males is 80.17+/-6.71 when compared with females 78.29+/-6.67 shows no significance.

**Table 12: Comparison of frontal sinus width between males and females**

| Group | | N | Mean | Standard Deviation | t | P | Inference |
|---|---|---|---|---|---|---|---|
| Width | Male | 75 | 23.93 | 7.59 | 0.517 | 0.606 (>0.05) | Not significant |
| | Female | 75 | 23.26 | 8.37 | | | |

The frontal sinus width in males is 23.93+/-7.59 when compared with females 23.26+/-8.37 shows no significance.

**Table 13. Comparison of frontal sinus length between males and females**

| Group | | N | Mean | Std. Deviation | t | P | Inference |
|---|---|---|---|---|---|---|---|
| Length | Male | 75 | 8.86 | 8.16 | 0.442 | 0.659 (>0.05) | Not significant |
| | Female | 75 | 8.43 | 1.73 | | | |

Frontal sinus length in males is 8.86+/-8.16 when compared with females 8.43+/-1.73 shows no significance.

**Table 14: Comparison of frontal sinus height between males and females**

| Group | | N | Mean | Std. Deviation | t | P | Inference |
|---|---|---|---|---|---|---|---|
| Height | Male | 75 | 10.89 | 2.61 | 5.512 | 0.0001 (<0.01) | Highly significant |
| | Female | 75 | 8.91 | 1.71 | | | |

The frontal sinus height in males is 10.89+/-2.61 when compared with the females 8.91+/-1.71 shows highly significant.

**Table 15: Canonical discriminant functions for Mmaxillary sinus right width between males and females**

| Eigenvalues | | | | |
|---|---|---|---|---|
| **Function** | **Eigenvalue** | **% of Variance** | **Cumulative %** | **Canonical Correlation** |
| 1 | 0.063[a] | 100.0 | 100.0 | 0.244 |
| **a. First 1 canonical discriminant functions were used in the analysis.** | | | | |
| **Wilks' Lambda** | | | | |
| **Test of Function(s)** | **Wilks' Lambda** | **Chi-square** | **Df** | **Sig.** |
| 1 | 0.940 | 9.061 | 1 | 0.003 |

**Table 16: Canonical discriminant functions for maxillary sinus left width between males and females**

| Eigenvalues | | | | |
|---|---|---|---|---|
| **Function** | **Eigenvalue** | **% of Variance** | **Cumulative %** | **Canonical Correlation** |
| 1 | 0.015[a] | 100.0 | 100.0 | 0.123 |
| **a. First 1 canonical discriminant functions were used in the analysis.** | | | | |
| **Wilks' Lambda** | | | | |
| **Test of Function(s)** | **Wilks' Lambda** | **Chi-square** | **Df** | **Sig.** |
| 1 | 0.985 | 2.261 | 1 | 0.133 |

**Table 17: Canonical discriminant functions for maxillary sinus right length between males and females**

| Eigenvalues | | | | |
|---|---|---|---|---|
| **Function** | **Eigenvalue** | **% of Variance** | **Cumulative %** | **Canonical Correlation** |
| 1 | 0.121[a] | 100.0 | 100.0 | 0.329 |
| **a. First 1 canonical discriminant functions were used in the analysis.** | | | | |
| **Wilks' Lambda** | | | | |
| **Test of Function(s)** | **Wilks' Lambda** | **Chi-square** | **Df** | **Sig.** |
| 1 | 0.892 | 16.854 | 1 | 0.0001 |

**Table 18: Canonical discriminant functions for maxillary sinus left length between males and females**

| Eigenvalues | | | | |
|---|---|---|---|---|
| **Function** | **Eigenvalue** | **% of Variance** | **Cumulative %** | **Canonical Correlation** |
| 1 | 0.005[a] | 100.0 | 100.0 | 0.068 |
| **a. First 1 canonical discriminant functions were used in the analysis.** | | | | |
| **Wilks' Lambda** | | | | |
| **Test of Function(s)** | **Wilks' Lambda** | **Chi-square** | **Df** | **Sig.** |
| 1 | 0.995 | 0.677 | 1 | 0.411 |

**Table 19: Canonical discriminant functions for maxillary sinus right height between males and females**

| Eigenvalues | | | | |
|---|---|---|---|---|
| **Function** | **Eigenvalue** | **% of Variance** | **Cumulative %** | **Canonical Correlation** |
| 1 | 0.551[a] | 100.0 | 100.0 | 0.596 |
| **a. First 1 canonical discriminant functions were used in the analysis.** | | | | |
| **Wilks' Lambda** | | | | |
| **Test of Function(s)** | **Wilks' Lambda** | **Chi-square** | **Df** | **Sig.** |
| 1 | 0.645 | 64.774 | 1 | 0.0001 |

**Table 20: Canonical discriminant functions for maxillary sinus left height between males and females**

| Eigenvalues | | | | |
|---|---|---|---|---|
| **Function** | **Eigenvalue** | **% of Variance** | **Cumulative %** | **Canonical Correlation** |
| 1 | 0.000[a] | 100.0 | 100.0 | 0.008 |
| **a. First 1 canonical discriminant functions were used in the analysis.** | | | | |
| **Wilks' Lambda** | | | | |
| **Test of Function(s)** | **Wilks' Lambda** | **Chi-square** | **Df** | **Sig.** |
| 1 | 1.000 | 0.010 | 1 | 0.921 |

## Discussion

In the present study we have included CT images of 150 subjects (75 males and 75 females) and different parameters of maxillary sinus (MS) and frontal Sinus (FS) were estimated for gender dimorphism the parameters for MS includes maximum mediolateral with (mm) of right and left side, anteroposterior height of right & left side, volume of right and left side and total distance across MS were measured from axial images with respect to frontal sinus (FS) maximum medio-lateral width (mm), anteroposterior length and maximum height was measured from scout image.

In the present study the MS mediolateral width of right side for males was 22.51 ± 2.82 when compared with females (24.48 ± 4.33) shows highly significant and MS mediolateral width of left side for males 23.84 ± 4.11 when compared with females 22.83 ± 4.07 showed no significance. Previous studies by Asmaa T. Uthman er al [10] hane stated the mean value for the mediolateral width of MS for male group was (24.7 ± 4mm) for right side and (25.6 ± 4.4 mm) for the left side with statistical significance female group had statistically significant lower values for both right and left sides (22.7 ± 3.2 and 23 ± 4 mm) respectively ($P < 0.05$).

Similar studies by Ahmed A. masir et al [11] and permilla sah lstrand- Johnson et al [12] stated that males exhibit higher and wide maxillary sinuses but the results of the present study mediolateral width is inconsistent with previous reports the right maxillary sinus showed highly significance and left side no significance.

In this study the antero posterior length of right side for male and female was 32.66 ± 4.65 and 36 ± 5.03 which showed statistically significant p vale of 0.0001 the AP of left side in male and female was 34.12 ± 7.37 & 3.33 ± 4.44 which showed no statistical significance p value 0.411.

Mass arat Jaha et al [13] reported in a study that AP length of MS in male was 36 ± 4.26 mm when compared with female it was larger (34.93 ± 4.14 mm) with significant p value. In another retrospective study by balaji Babu Bangi et al [14] The anteroposterior length for right side in males and females was 3.576 ± 0.413 and 3.376 ± 0.413 and left side it was 3.559 ± 0.385 and 3.384 ± 0.388 respectively.

The P value (> 0.05) did not showed significance. The results of the present study is similar to the previous study by balaji Babu Bangi et al where the results were insignificant in the present study the MS left height in males is 26.6 ± 5.23 when compared with females 26.67 ± 4.28 shows no significance and right height in males 27.81 ± 4.82 when compared with females 21.45 ± 3.72 shows highly significant.

In the present study the right MS volume in males is 10.41 ± 2.48 when compared with females 10.16 ± 3.90 shows no significance and left MS volume in males is 11.32 ± 3.82 when compared with females 10.67 ± 3.5 shows no significance.

The mean value of maxillary sinus volume has been studied by several researches.

A study done by Pernilla sahistrand-Johson et al [12] found the mean values of the maxillary sinus volume have been reported to range from 11.1 ± 4.5 $cm^3$ to 23.0 ± 6.7 cm [3].

According to Ariji et al [15] the volume of maxillary sinus ranged from 4.56 – 35.21 $cm^3$ mean (14.71 ± 6.33 cm3) in patients aged over 20 years.

According to Ahmed A masir et al [13] The maxillary sinus increased in sizes and volume from birth to 30 years of age.

In the present study the total distance across the maxillary sinus in males and females was 80.17 ± 6.71 and 78.29 ± 6.67 which showed no significance.

Previous study by Asmaa T. Uthman er al [15] The total distance across the MS was calculated as 82.4 ± 7.7 mm for male group and 77.9 ± 6.2 mm for female group.

In the present study frontal sinus width between males and females was 23.93 ± 7.59 & 23.26 ± 8.37 which shows no significance.

In the present study the frontal sinus length in males and females is 8.86 ± 8.16 & 8.43 ± 1.73 with p vale 0.659 which shows no significance.

In the previous studies by Tattisumak et al [16] The AP length of FS for males and females was calculated as 13.15 ± 5.23 and 10.80 ± 4.10.

A.T Uthman et al [15] conducted a study on frontal sinus to identify unknown individual The AP length was measured from scout image which was similar to Tatllisumak et al and A.T Uthman et al.

In the present study FS height between males and females was 10.89 ± 2.61 and 8.91 ± 1.71 which shows highly significant.

CT scan provides crucial role in depicting the structures and its extension to adjacent structures. In a recent report by Rennie et al[17]. The pyramids form of the maxillary sinus was present in 52.4%. Five different anterior shapes were reported. Type 1 (triangular), Type 2 (upside down triangle),

**Conclusion**

Computed tomography provides an excellent method for imaging maxillofacial region. It has been stated in literature that skull remains intact despite other bones are disfigured. Personal identification is the primary area of concern in forensic from the present study results we conclude that dimensions of frontal and maxillary sinus can be used for gender dimorphism and proves vital in identifying gender of a person in forensic anthropology.

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