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Significance of Frontal Sinus and Nasal Septum Patterns in Personal Identification in Forensics: A Prospective CBCT Study

Shalini S*, Nagaraju K, Sangeeta M, Sumit G, Swati G and Abhinav A

Department of Oral Medicine and Radiology, Subharti Dental College and Hospital, Swami Vivekanand Subharti University, Meerut, India

***Corresponding Author**

Shalini S, Department of Oral Medicine and Radiology, Subharti Dental College and Hospital, Swami Vivekanand Subharti University, Meerut, India, Tel: 7351449593, Email: dr.shalinisharma23@gmai.com

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Abstract

Background: The radiographic examination of skull is an utmost useful procedure in personal identification of cases (mass disasters & crimes) in which the remnants of skull persist with no chance of identification based on dental structures. A significant correlation is found between patterns of NS and FS, hence combined use of FS and NS patterns could strongly be used in forensics for identification. Aim: To evaluate the uniqueness & reliability of combined Frontal Sinus (FS) & Nasal Septum (NS) patterns as observed on full skull projections on Cone Beam Computed Tomography (CBCT) for personal identification.

Material & method: It is a prospective study which carried out for patients of 18 months and full skull CBCT projections of 150 individuals (age ranging from 20-50 yrs) of North Indian population, taken for diagnostic purposes (dental implant surgery, tumors, cysts, embedded teeth) were included.

Results: Frontal sinus symmetry was observed in 97 (64.67%) individuals and asymmetry in 36 (24%) individuals. Unilateral Aplasia of frontal sinus was seen in 12(8%) individual and the frontal sinuses were absent (bilateral Aplasia) in 5 (3.33%) individuals. Right deviation of nasal septum was seen in 65 (43.33%) individuals and left deviation of nasal septum was observed in 59 (39.33%) individuals. Straight nasal septum pattern was seen in 15 (10.00%) individuals. Sigmoid pattern was noticed in 10 (6.67%) individuals and reverse sigmoid pattern was observed in 1 (0.67%) individual.

Conclusion: The mean dimension of left FS was comparatively larger in males while the right FS dimension was larger in females. In male's deviation of nasal septum is more on right side as compared to females which is more on left side. Frontal sinus in conjunction with nasal septum patterns can be used as a diagnostic tool for personal identification in forensics.

Keywords: Frontal sinus, Nasal septum, Forensic Science, CBCT, Personal Identification

Introduction

A man is born with an identity and justifies dying with the same. All human beings inhabited this earth belong to the same species i.e. Homo sapiens. No two individuals are exactly alike, even monozygotic twins differ in some aspects. There is certain body structure which have tendency to undergo change in varying degree from birth to death, in health & disease. In the development of skeleton various factors have an effect on producing variance in skeletal proportion among different geographic regions. Anthropometry is the technique of quantitative measurement of the human body used for identification, whether on living or dead or on skeletal evidence. Forensic medicine is a multidisciplinary science mainly deals with scientific examination and assessment (qualitative as well as quantitative) of individuals who have been or are suspected to have been injured or killed by external influence such as trauma or intoxication [1].

The uniqueness of anatomical structures and their discrepancy provide the basis for forensic identification of unknown diseased persons [2]. Fingerprint analysis, DNA matching, & anthropological studies can aid the process of individual recognition. French police officer, Alphonso Bertillion (1853-1914) fabricated the first anthropometric scientific system based on the physical measurement for identifying criminals in 1880 [3].

Skull has exponential potential in identifying an individual, which is attributed to the presence of several structures that can be used in identification, such as dentition, cranial patterns, paranasal sinuses & nasal septum [3].

Frontal sinuses (FS) are not evident at the time of birth and begin to develop during the second year of life [4]. Frontal sinus (FS), the most anterior & superior paranasal sinus located within the frontal lobe is the last sinus to develop & is comprised of two symmetric pneumatic compartments divided by a septum which continued with the Crista galli & cribriform plate of the ethmoid inferiorly. It is lined by a mucous membrane illustrated respiratory epithelium with variable normal thickness of 0.07-2mm, able to secret a moistening & protective fluid which provide immune defense & air filtration. It serves various functions such as: reducing the weight of skull, humidifying & regulating air temperature [5].

Radiographically frontal sinus is not visible until the age of five yrs. Belaldavar C et al ascertained that the development of the frontal sinus is completed by about 20 yrs of age & remains stable until further enlargement of the chambers which occurs as a consequence of bone resorption during advanced age [4].

Frontal sinus which is very resistant to trauma, likely to remain preserved in dismembered or burn corpses after mass disasters such as air crush [6].

In 1921, Schuller first studied frontal sinus & revealed its uniqueness in shape, complexity & individuality. Along with nasal septum patterns frontal sinus provides most interesting & significant information in forensic identification [7].

In the late nineteenth century the first detailed and systematic anatomical and physiological description of the paranasal sinuses were published by Zukerkandle [8].

As cone beam computed tomography is a precise & fast method it can be used to evaluate high resolution images depicting structural details. 3D scanning of area of interest, reduced radiation dosage & exposure time, and rendering superior quality images make CBCT better choice compared to conventional computed tomography (CT) [9].

The purpose of the present study was to inspect & identify the various frontal sinus patterns & nasal septum patterns present and assess their usefulness in personal identification in forensics using CBCT radiographs.

Materials and Methods

The study was carried out on 150 CBCT projections between the age group of 20 and 50, visiting the Department of Oral Medicine and Radiology, at Subharti Dental College and Hospital, Meerut. The radiographic data/slices were observed for frontal sinus and nasal septum patterns. The frontal sinus was evaluated for symmetrical, asymmetrical (right or left), unilateral aplasia (right or left) and bilateral aplasia. (fig.1) [10].
The formula for calculation of symmetry was the greatest

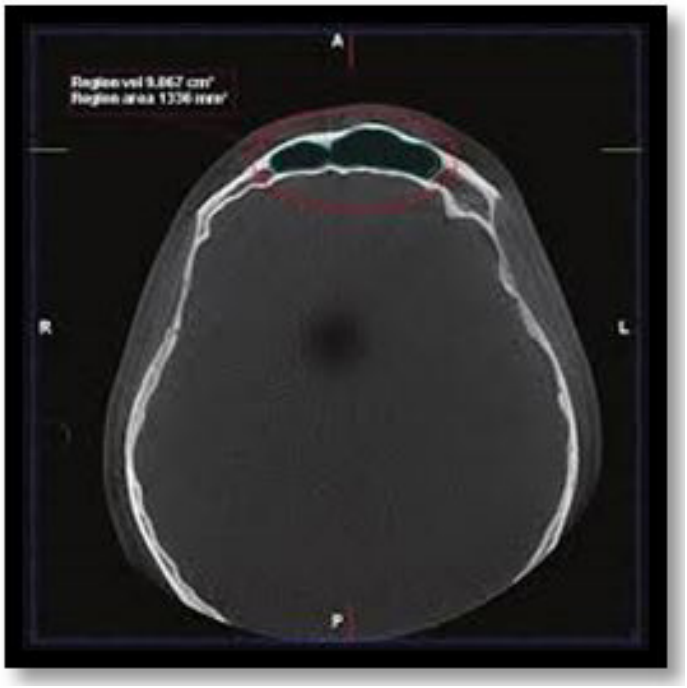


Figure 1: Frontal sinus

dimension horizontally was measured from the central septum on both sides. The difference between the right and left side dimensions was divided by the greatest dimension and then multiplied by 100 [10].

If the percentage was below 20 it was considered symmetrical and vice versa.

[Right side dimension ~ Left side dimension] x 100

Greatest dimension

The nasal septum was classified according to deviation in septa as straight, simple deviation to the right or left side, sigmoid & reverses sigmoid type. (fig.2) [10]. The combined frontal sinus & nasal septum was recorded for each individual and all the results obtained were tabulated and statistically analyzed (figure 3,4).

Figure 2: Nasal Septum

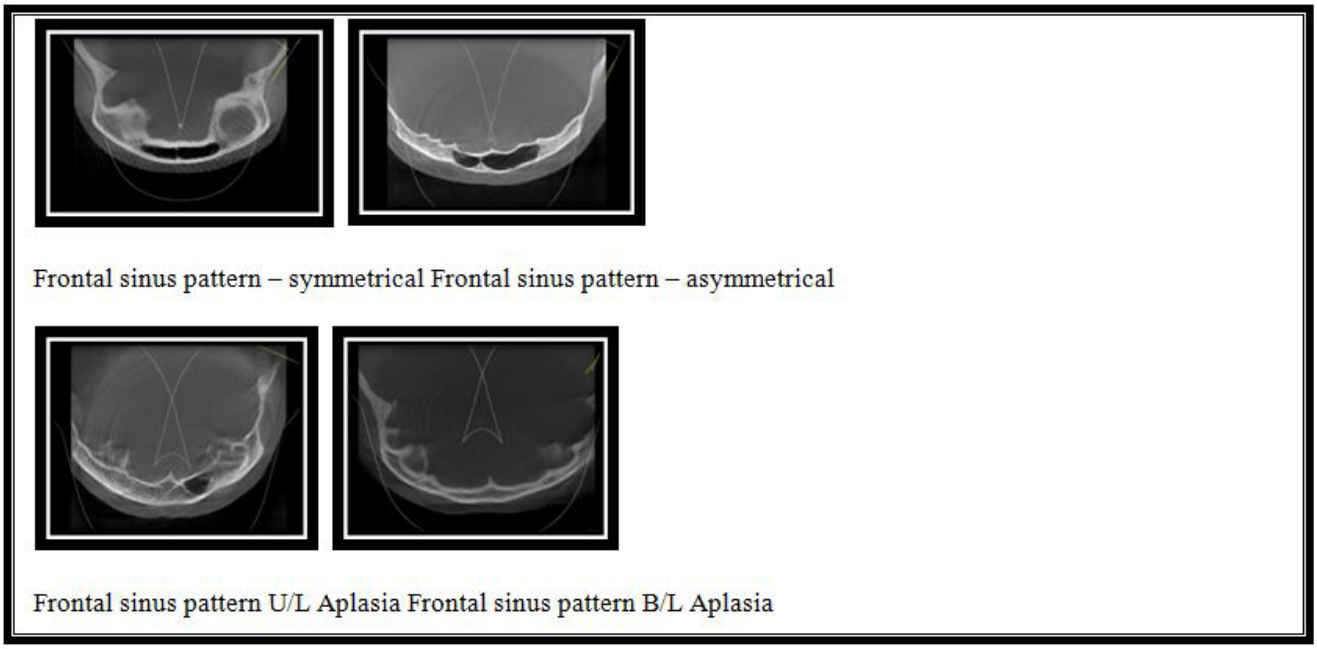


Figure 3: Various pattern of frontal sinus seen in CBCT images

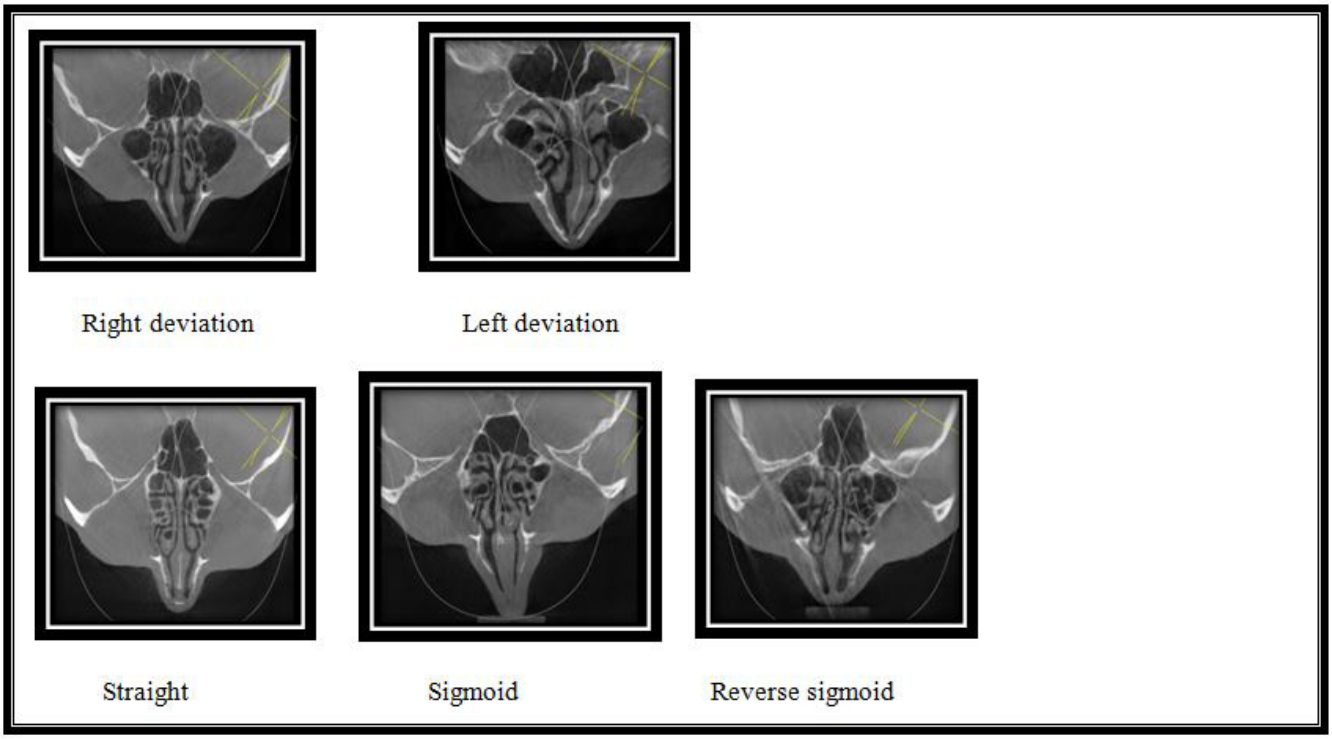


Figure 4: Various patterns of nasal septum seen in CBCT image

Based on the age, the study was carried out in 3 groups:

Group I: consisted of 50 CBCT images obtained from age ranges from 21-30 years.

Group II: consisted of 50 CBCT images obtained from age ranges from 31-40 years.

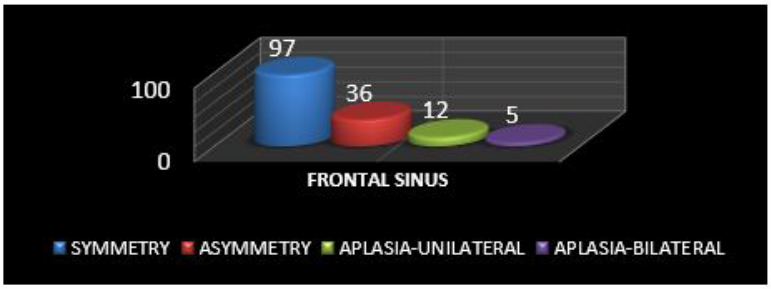
Group III: consisted of 50 CBCT images obtained from age ranges from 41-50 years.

The frontal sinus symmetry was observed in 97 individuals (53 males &44 females) (64.67%). Asymmetry was observed in 36 individuals (14 males & 22 females) (24%). Unilateral Aplasia of frontal sinus was seen in 12individuals (6 males & 6 females) (8%). The frontal sinus was absent (bilateral Aplasia) in 5 individuals (2 males & 3 females) (3.33%). (Table & Graph 1)

Right deviation of nasal septum was seen in 65 individuals (43 males & 22 females) (43.33%). Left deviation of nasal septum was observed in 59 individuals (22 males & 37 females) (39.33%).

Table 1: Number of individual exhibiting each type of frontal sinus pattern

Frontal sinus	Female	Male	Total	Percentage (%)
Symmetry	44	53	97	64.67%
Asymmetry	22	14	36	24.00%
Aplasia-unilateral	6	6	12	8.00%
Aplasia-bilateral	3	2	5	3.33%
	75	75	150	100.00%



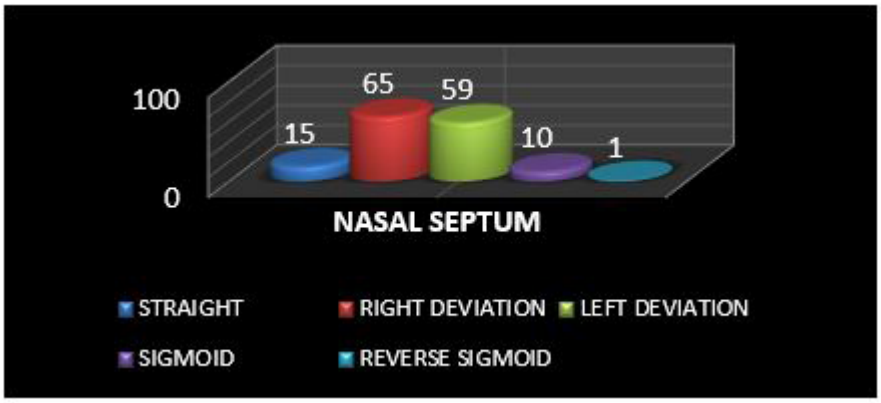
Graph 1: Number of individual exhibiting with each type of frontal sinus pattern

Straight nasal septum pattern was seen in 15 individuals (5 males & 10 females) (10.00%). Sigmoid pattern was noticed in 10 individuals 94 males & 6 females) (6.67%) and reverse sigmoid pattern was observed in 1 individual (1male & o female) (0.67%) (Table & Graph 2) (Table 3-5)

In our study the dimension of frontal sinus of each individual was observed and found to be unique. This clearly depicts the uniqueness of frontal sinus in forensic identification.

Table 2: Number of individuals presenting with each t6ype of nasal septum pattern

Nasal septum	Female	Male	Total	Percentage (%)
Right deviation	22	43	65	43.33%
Left deviation	37	22	59	39.33%
Straight	10	5	15	10.00%
Sigmoid	6	4	10	6.67%
Reverse sigmoid	0	1	1	0.67%
	75	75	150	100.00%



Graph 2: Number of individuals exhibiting with each type of nasal septum pattern

Table 3: Combined patterns of frontal sinus and nasal septum

Frontal sinus	Female	Percentage (%)	Male	Percentage (%)
Symmetry	44	59%	53	71%
Asymmetry	22	29%	14	19%
Aplasia-Unilateral	6	8%	6	8%
Aplasia-Bilateral	3	4%	2	3%
	75	100%	75	100%
Nasal Septum				
Straight	10	13%	5	7%
Right Deviation	22	29%	43	57%
Left Deviation	37	49%	22	29%
Sigmoid	6	8%	4	5%
Reverse Sigmoid	0	0%	1	1%
	75	100%	75	100%

Table 4: Combined patterns of frontal sinus and nasal septum in females

Classification	Number Of Individuals							
Frontal Sinus	**20-30 female**		**30-40 female**		**40-50 female**			
Symmetry	12	48%	18	72%	14	56%	44	59%
Asymmetry	10	40%	5	20%	7	28%	22	29%
Aplasia-Unilateral	1	4%	1	4%	4	16%	6	8%
Aplasia-Bilateral	2	8%	1	4%	0	0%	3	4%
	25	100%	25	100%	25	100%	75	100%
Nasal Septum								
Straight	2	8%	6	24%	2	8%	10	13%
Right Deviation	9	36%	7	28%	6	24%	22	29%
Left Deviation	14	56%	10	40%	13	52%	37	49%
Sigmoid	0	0%	2	8%	4	16%	6	8%
Reverse Sigmoid	0	0%	0	0%	0	0%	0	0%
	25	100%	25	100%	25	100%	75	100%

Table 5: Combined patterns of frontal sinus and nasal septum in males

Classification	Number Of Individuals							
Frontal Sinus	**20-30 male**		**30-40 male**		**40-50 male**			
Symmetry	16	64%	19	76%	18	72%	53	71%
Asymmetry	7	28%	4	16%	3	12%	14	19%
Aplasia-Unilateral	0	0%	2	8%	4	16%	6	8%
Aplasia-Bilateral	2	8%	0	0%	0	0%	2	3%
	25	100%	25	100%	25	100%	75	100%
Nasal Septum								
Straight	5	20%	0	0%	0	0%	5	7%
Right Deviation	12	48%	19	76%	12	48%	43	57%
Left Deviation	4	16%	6	24%	12	48%	22	29%
Sigmoid	3	12%	0	0%	1	4%	4	5%
Reverse Sigmoid	1	4%	0	0%	0	0%	1	1%
	25	100%	25	100%	25	100%	75	100%

Discussion

Identification of gender of unknown persons is of utmost important in forensic investigations, like anthropologic, medical and dental forensic studies [11]. The uniqueness of the frontal sinus anatomical cavity, which is not even repeated in monozygotic twins, establishes its significance in forensic community [12]. Combined frontal sinus & nasal septum patterns may also be helpful for identification and gender determination of an individual in forensic study [13].

Radiographic assessment of various skeletal structures together with skull is potentially effective for identification either in human remains or in living person [14].

Compared to CT, the low dosing requirements, high-quality bony definition and the compact design afforded by CBCT scanners have made them appealing for office-based and intra-operative scanning of frontal sinuses [15].

As the development of frontal sinus goes up to 20 years and the growth of nose increases up to 18 years of age, the study included the individuals from the age group of 20-50 years.

Our study showed symmetrical frontal sinus seen in 97 patients (64.67%) which was in accordance with that of the study conducted by Kavita Verma [16] et.al. (77.50%). K Saraswathi Gopal et al. [3] studied on 80 individuals & observed that frontal sinuses were absent (bilateral Aplasia) in four individuals (5%). Unilateral Aplasia was seen in two individuals (2.5%), in our study B/L Aplasia seen in 3.33% & U/L Aplasia seen in 8% individuals. The variation may due variation in sample size, while symmetrical & asymmetrical patterns of frontal sinus resembles to our study. Isabela G. G. Choi [12] conducted a study in which absence of frontal sinus (B/L Aplasia) was not observed in their study while our study showed 3.33% B/L Aplasia of frontal sinus. The present study differed from that done by Taniguchi M et al., [17] in various aspects. They demonstrated that, 43.1% cases had symmetry of frontal sinus and 56.6% had asymmetrical patterns which are contrary to findings of our study (64.67% symmetrical and 24% asymmetrical patterns of frontal sinus). Our findings were consistent with the results reported by Maria Priscilla David et al. which showed that Frontal sinus symmetry was observed in 29 (58%) individuals and asymmetry was observed in 16 (32%). Complete absence of frontal sinuses (bilateral aplasia) seen in two individuals (4%). Unilateral aplasia was noticed in three individuals (6%) [10].

Maria Priscilla David et al. conducted study and noticed that the straight nasal septum was seen in 22%, right deviation in 42%, and left deviation in 30% individuals [10]. Sigmoid was seen in 2%, reverse sigmoid in 2% which were 6.67% & 0.67% respectively in our study. Taniguchi et al. [17] reported highest cases of left deviation of nasal septum 36.7% whereas present study showed highest reported case of right nasal septum 43.33%. Straight nasal deviation noted in 13% individuals in Taniguchi et al. study which is consistent with our study 10%. K Saraswathi Gopal et al [3] observed Sigmoid & reverse sigmoid data (5% & 8.75% respectively) which were varied as compared to our case with 6.67% & 0.67% respectively.

The drawback of our study is smaller sample size. In future further study with large sample size is required to study this correlation and significance.

Conclusion

The parameter discussed in our study showed considerable individual variation in the nasal septum and frontal sinus pattern as viewed in full skull cone beam computed tomography images. In present study the mean value of horizontal dimensions was greater for males than females in North Indian population. The mean dimension of left FS (≈ 28mm) was comparatively larger in males while the right FS dimension (≈ 26mm) was larger in females (Table 6 & 7)

The significant difference was also observed in nasal septum patterns for male & female. In male's deviation is more on right side as compared to females which is more on left side. So it is concluded that male nasal septum is righter and the female septum is more left.

No statistically significant difference was found between age groups and measurements of frontal sinus.

Thus, our findings show that frontal sinus and nasal septum parameters can be used along with other factors for personal identification in mass disaster, crime scenes or if the body is severely decomposed.

Further studies are recommended to carry out research on a wide population size to achieve the accuracy level in gender determination.

Table 6: t- test

t-Test: Paired Two Sample for Means		
	Mean of RT FS Female	**Mean of RT FS Male**
Mean	26.58748333	27.23667
Variance	3.369405938	4.839577935
Observations	3	3
Pearson Correlation	0.929700498	
Hypothesized Mean Difference	0	
df	2	
t Stat	-1.343484575	
P(T<=t) one-tail	0.155627736	
t Critical one-tail	2.91998558	
P(T<=t) two-tail	0.311255471	
t Critical two-tail	4.30265273	

Table7: t- test

t-Test: Paired Two Sample for Means		
	Mean of LT FS Female	**Mean of LT FS Male**
Mean	26.15605	28.77102667
Variance	5.865829427	0.085549354
Observations	3	3
Pearson Correlation	-0.574303422	
Hypothesized Mean Difference	0	
df	2	
t Stat	-1.741378624	
P(T<=t) one-tail	0.111871389	
t Critical one-tail	2.91998558	
P(T<=t) two-tail	0.223742779	
t Critical two-tail	4.30265273	

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