

Age and Gender Determination using Maxillary Sinus and Sella Turcica on Lateral Cephalogram: A Retrospective Digital Radiographic Study

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Abstract

Background: Anthropometry is of immense importance in human identification and plays a major role in medico legal investigation of demise. Lateral cephalogram provides architectural, morphological details of skull and multiple points for comparison also presents various anatomical landmarks. The study aimed to evaluate morphometric analysis of Maxillary sinus & Sella turcica parameters in gender determination & age estimation.

Methodology: The study included 300 digital Lateral cephalograms of age range 10-40 years divided in to 3 groups & 50 males and 50 females in each age group. Linear measurement was performed for Maxillary Sinus Height, Width and Index & Sella turcica (ST) Length, Depth and Diameter. Results indicated that all the study parameters were found to be statistically significant in determination of age except Sella turcica depth. Maxillary sinus parameters & Sella turcica diameter, length showed significant correlation between age group Group-I and Group-II. Maxillary sinus width, height & Sella turcica length was found to be statistically significant in determination of gender. Discriminant equation of MS width had highest accuracy of 63.7% in determination of gender.

Conclusion: Lateral Cephalogram can be used to determine age and gender using linear measurements of maxillary sinus and Sella turcica.

Keywords: Maxillary sinus; height; width; index, Sella turcica; depth; diameter; length.

Introduction

Forensic odontology is proper handling, examination and evaluation of dental evidence also it has significant outgrowth in forensic medicinal sciences in providing justice by identifying the

human remains of victims in catastrophic events, radiologic and chemical explosives, mass disaster. The fundamental principle in identifying in dental evidence is by comparing antemortem and postmortem records.^{1,2} primary bone that is used in

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sex determination is pelvic bone and the second most common bone used is skull bone which manifests the sexual characteristics during puberty.³ Age estimation is one of the several indicators employed in forensic cases which also has the importance in civil rights and social benefits.⁴

Radiographs are indispensable tools in forensic anthropology which is simplest and cheapest method compared to histological and biochemical methods in identification of humans. The accuracy depends on the quality of radiographs.⁵ Various researchers have alleged that conventional radiograph as cost effective, easily available, and reliable in providing accuracy of 80–100%.⁶

Cephalometric landmarks like maxillary sinus and Sella turcica an anatomical structure in the middle cranial fossa of skull, which is bounded anteriorly by tuberculum sellae, posteriorly by dorsum sellae and inferiorly by the bony roof of the sphenoidal air sinus. can be used in gender and age determination.⁷

In the view of the above literature, this study intends to provide the tool for determination of age and gender in forensic odontology using two craniofacial landmarks i.e., Maxillary Sinus and Sella turcica from lateral cephalograms by linear measurements.

Materials and Methods

The study conducted included 300 lateral cephalograms between age about 11-40. The age groups were divided in to three groups with equal distribution of gender in each group. Lateral digital cephalograms images of the patients advised Lateral cephalogram for purpose of orthodontic treatment, good quality digital lateral cephalogram images are included. Lateral cephalogram images of the patients with congenital, developmental anomalies or pathology in the maxillary sinus, history of trauma and bone disorders, incomplete patient records, poor quality images & images that do not cover the area of interest are excluded from the study.

Method of study

The study is a lateral cephalometric retrospective radiographic study carried out for 2 years. The ethical clearance was obtained from institutional

ethical committee of Al-Badar Rural Dental College & Hospital with registration number EC/NEN/INST/2022/2710. The conducted study comprised of 300 lateral cephalograms with equal distribution of gender with 50 males and 50 females in each age groups. Lateral cephalograms were collected from the archives of Department of Oral Medicine and Radiology. The age groups were divided in to three.

Group 1: 11-20 years.

Group 2: 21-30 years.

Group 3: 31-40 years.

The lateral cephalograms were obtained from Toshiba Panoramic device under standard exposure conditions recommended by manufacturer i.e., 80kv 10.0mA, 10s & 37mGy.cm². The obtained lateral cephalograms included in the study were subjected to following digital measurements using CS Imaging software version-7.0.2. After 1 Month intra-observer observation was done which included 60 lateral cephalogram which were selected from previous 300 lateral cephalograms with equal distribution of gender in each age groups and digital measurements were done for the all-study parameters

The study included 2 landmarks parameters of maxillofacial complex.

Maxillary Sinus (MS).⁸

- Height(H)- measured from most Superior to the most Inferior point.
- Width(W)- measured from most anterior to most posterior point.
- Maxillary Sinus Index(W/H)- The ratio of maxillary sinus width to height is taken as Maxillary sinus index

Sella Turcica (ST).⁹

- **Length:** The distance between the tuberculum Sella and the tip of the dorsum Sella.
- **Depth:** The line perpendicular to the length to the inferior most point on the floor.
- **Diameter:** The distance between the tuberculum Sella and a point on the posterior inner wall of the pituitary fossa furthest from the tuberculum Sella.

Statistical analysis:

The collected data was subjected to statistical analysis using power package of R program software version 4.2.2. P value ≤ 0.05 was considered to be statistically significant. The mean p values for different age groups were obtained from the One-way ANOVA. The P value for gender distribution was done by student's t test. P value for all the study parameters between different age groups were compared using Tamhane POST hoc test. Discriminant analysis for each parameter was done & Discriminant equation was obtained find the accuracy for genders determination. After 1-month Intra observer observation was done for 60 lateral cephalograms which were selected from previous 300 lateral cephalograms in which 10 males & 10 females were included in each age group and were measured for the same parameters.

Result and Discussion

The study included total of 300 digital lateral cephalograms with equal gender distribution in each age groups. All the parameters of maxillary sinus and Sella turcica length and diameter were statistically significant according to age groups in which maxillary sinus Index presented with least p value 0.0015 indicating that it is better parameter to determine age (Table-1) which was in agreement with **Teixeira LC et al.**¹⁰ in which the age group they included were similar to our study. **Rani SU et al.**⁴ showed that Maxillary sinus height and width are greater in younger age group than older age groups and also maxillary sinus height has much probability to determine age when compared to maxillary sinus width similar results were observed in our study & showed that maxillary sinus height parameter had greater significance than maxillary sinus width.

In contrast to our study, a study conducted by **Najem SS et al.**⁵ revealed that Maxillary sinus Height and width cannot be used to determine age as their study sample included Egyptian patients whereas our study was done in Indians in order to avoid variations arising from ethnicity. This could explain why the results may not coincide with other studies that were conducted on different populations.

Sella Turcica length and diameter had positive results in determination of age among which Sella Turcica Length had greater significance whereas Sella turcica Depth was not significant which was in agreement with **Muhammed FK et al.**¹¹ in which they focused to evaluate the linear dimension of Sella turcica in Chinese and Nepalese which may be reason of similar ethnicity found in Indians.

In contrast to our study **Chaurasia A et al.**¹² revealed that there was no significant difference observed with ST Diameter. **Kumar TS et al.**¹³, **Nagaraj T et al.**¹⁴ suggested that Depth and diameter had the significant difference with age. **Sathyanarayana HP et al.**¹⁵ revealed that all the above parameters of Sella turcica have significant difference according to age. The above studies revealed that the Sella turcica parameters increases with the age.

Significant correlation between Group-I and Group-II was found with all the study parameters with p value < 0.005 . Maxillary sinus height having highest mean difference of 2 among all the study parameters, whereas for the Sella Turcica Parameters only Sella turcica diameter & Length had positive correlation only between age group-I (11-20) years & II (21-30) years with Sella turcica length having highest mean difference of 0.9 among Sella turcica parameters. (Table-2). **Subasree S et al.**⁹ revealed that the less mean difference was found with Sella turcica Depth in between age group-II (21-30) years & age group-III (31-40) years which was in agreement with our study. **Kumar TS et al.**¹³ also compared the linear measurements with different age groups it was noted that Sella turcica diameter had negative correlation between ≤ 10 years and 11-20 years which was not significant as the subjects in ≤ 10 years age groups were only 5 in number whereas in 11-20 years the subjects were 161 in number and also the age group was under developing stage.

The mean values of maxillary sinus width and height were found to be greater in males than females & were statistically significant. Maxillary sinus height parameter presented to be best indicator to determine gender. (Table-3) Our study was in consistent with **Urooge A et al.**¹⁶ who conducted a study on CBCT in which left Maxillary sinus width was the only study parameter found to be statistically significant with accuracy of 60%. The similarity could be because of

samples included were from same state (Karnataka) of India though the sample size was small. The other study was in agreement with our study was by **Velpula N et al.**⁸ which was conducted on lateral cephalograms in Telangana region with similar age range in our study. The Maxillary Sinus width parameter was found to be statistically significant in gender determination followed by Maxillary Sinus index with accuracy of 79%, with mean values for both parameters were higher in males than females with the above studies. Whereas our study revealed that, of all the study parameters Maxillary sinus width equation presented with highest accuracy of about 63.7% in determination of gender & Maxillary sinus Index was found to be statistically not significant with higher mean values in females compared to males. (Table-4) **Rani SU et al.**⁴ revealed that both Maxillary sinus Height and Width have the significance in determination of gender. But Maxillary Sinus height had greater significance followed by maxillary sinus width which was consistent with our study.

In contrast to our study **Khaitan T et al.**⁶ revealed that Maxillary sinus width was not significant & cannot be used for determination of gender, but Maxillary Sinus height was found to highly significant followed by Maxillary sinus index in determination of gender this may be due to less sample size included in their study in west Bengal population. The study done in Chennai population by **Subasree S et al.**⁹ was in partial disagreement with our study as their study revealed that maxillary sinus width parameter was a poor indicator to determine gender, and for Maxillary sinus index similar results were noted that it was not significant for gender determination, whereas Maxillary height had highest significance for gender determination. **Sathawane SR, et al.**¹⁷ conducted a study using CBCT which included Maxillary Sinus parameter like height, width & length which were measured bilaterally to determine gender & their study revealed that all the study parameters were significant except left maxillary sinus width.

In our study only Sella turcica length had mean values greater in males than in females and was significant for gender determination among all the study parameters of Sella turcica with accuracy of 57% for discriminant analysis of Sella turcica length (Table-4). Whereas other study parameters

of Sella turcica width and diameter had higher mean values in females compared to males and were statistically not significant. Our study was in agreement with **Sathyanarayana HP et al.**¹⁵ which revealed that Sella turcica length is significant in gender determination as it was done in Indian population.

In contrast to our study **Kiran C et al.**¹⁸ revealed that Sella turcica diameter and depth both had significance in gender determination. The mean values were greater in males than in females which was contradictory with mean values in our study. Although the sample size was smaller that may be the reason for variation of results.

A study by **Badri MK, Alhojaily et al.**¹⁹ revealed that all parameters of Sella turcica were significant in gender determination in Saudi Arabia population with less sample size. **Arthisri A et al.**²⁰, **Chaurasia A et al.**¹², **Muhammed FK et al.**¹¹ **Subasree S et al.**⁹ & **Kumar TS et al.**¹³ revealed that all the study parameters of Sella turcica were found to be statistically not significant in gender determination as there was unequal distribution of subjects & small sample size.

All the study parameters were found to be statistically not significant between observation-1 & 2. None of the study discussed for intra observer comparison. (Table-5)

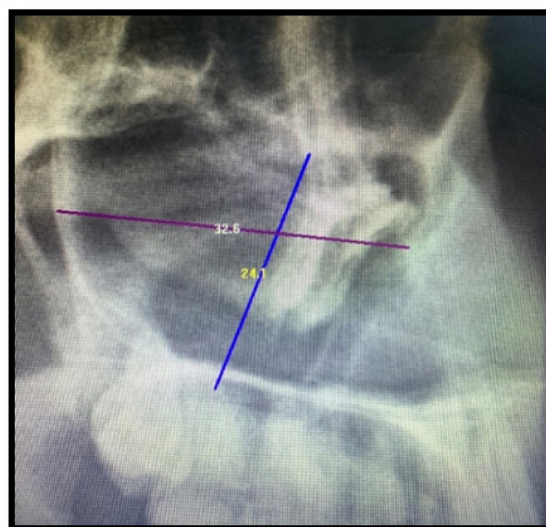


Figure 1: Linear Measurement of Maxillary Sinus showing

WIDTH-32.6 mm; HEIGHT-24.1mm

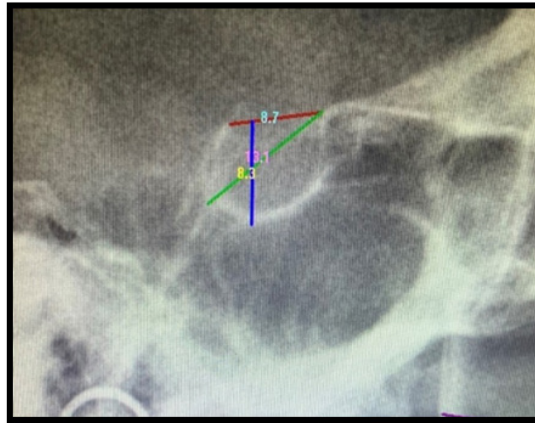


Figure 2: Linear Measurement of Sella Turcica showing
LENGTH-8.7mm; DEPTH-8.3mm; DIAMETER-13.1mm

Table 1: To Compare means of Maxillary sinus and Sella turcica study parameters between age groups using ANOVA

PARAMETERS		AGE GROUP (YEARS)		
		I (11-20) YEARS	II (21-30) YEARS	III (31-40) YEARS
MS WIDTH (MSW)	Mean	34.3	35.6	34.6
	SD	4.08	3.38	4.15
	P value	0.0494(S)*		
MS HEIGHT (MSH)	Mean	23.7	25.7	24.4
	SD	3.83	3.94	4.90
	P value	0.0028(S)*		
MS INDEX (MSI)	Mean	1.8	1.2	1.4
	SD	1.97	0.37	0.24
	P value	0.0015(S)*		
ST DEPTH (STd)	Mean	8.4	8.5	8.7
	SD	1.59	1.67	1.34
	P value	0.358(NS)		
ST DIAMETER (STDmt)	Mean	11.9	12.5	12.0
	SD	1.46	1.77	1.63
	P value	0.015(S)*		
ST LENGTH (STL)	Mean	8.9	9.7	9.5
	SD	1.73	1.98	1.71
	P value	0.0037(S)*		

MS-Maxillary sinus; ST-Sella turcica.

p value \leq 0.005-statistically significant*; p value \geq 0.005-Not statistically significant

Table 2: Comparison of all the study parameters among age groups using Tamhane Post Hoc

VARIABLES	BETWEEN	DIFFERENCE	P VALUE
MS WIDTH (MSW)	Group I and Group II	1.3	0.0522*
	Group I and Group III	0.3	0.8746
	Group II and Group III	1.0	0.1567
MS HEIGHT (MSH)	Group I and Group II	2.0	0.0021*
	Group I and Group III	0.7	0.4416
	Group II and Group III	1.3	0.0740
MS INDEX (MSI)	Group I and Group II	0.6	0.0009*
	Group I and Group III	0.4	0.2301
	Group II and Group III	0.2	0.2302
ST DEPTH (STd)	Group I and Group II	0.1	0.8833
	Group I and Group III	0.3	0.3364
	Group II and Group III	0.2	0.6176
ST DIAMETER (STDmt)	Group I and Group II	0.6	0.0161*
	Group I and Group III	0.1	0.8176
	Group II and Group III	0.5	0.0779
ST LENGTH (STL)	Group I and Group II	0.9	0.0029*
	Group I and Group III	0.6	0.0662
	Group II and Group III	0.3	0.5326

MS-Maxillary sinus; ST-Sella turcica,

p value ≤ 0.005 -statistically significant*; p value ≥ 0.005 -Not statistically significant

Table 3: Student t test to compare means and Standard deviation (SD) between gender

PARAMETER		GENDER	
		MALE	FEMALE
MS WIDTH (MSW)	Mean	35.9	33.8
	SD	4.00	3.53
	P value	0.0045(S)*	
MS HEIGHT (MSH)	Mean	25.5	23.7
	SD	4.27	4.21
	P value	0.0004(S)*	
MS INDEX (MSI)	Mean	1.40	1.48
	SD	0.27	1.66
	P value	0.5553(NS)	
ST DEPTH (STd)	Mean	8.4	8.6
	SD	1.52	1.56
	P value	0.2299(NS)	
ST DIAMETER (STDmt)	Mean	12.0	12.3
	SD	1.73	1.53
	P value	0.0604(NS)	
ST LENGTH (STL)	Mean	9.6	9.1
	SD	2.03	1.60
	P value	0.0121(S)*	

MS-Maxillary sinus; ST-Sella turcica,

p value ≤ 0.005 -statistically significant*; p value ≥ 0.005 -Not statistically significant

Table 4: Gender determination by discriminant equations and its percentage accuracy

PARAMETER	EQUATION	PERCENTAGE ACCURACY (%)
MS WIDTH (MSW)	$-0.7110+0.0347(\text{MS WIDTH})$	63.7
MS HEIGHT (MSH)	$-0.0749+0.0234(\text{MS HEIGHT})$	59.7
MS INDEX (MSI)	$0.5208-0.0144(\text{MS INDEX})$	51.3
ST DEPTH (STd)	$0.6927-0.0226(\text{ST DEPTH})$	49.0
ST DIAMETER (STDmt)	$0.9019-0.0331(\text{ST DIAMETER})$	53.0
ST LENGTH (STL)	$0.1322+0.0393(\text{ST LENGTH})$	57.0
ST LENGTH (STL)	$0.1322+0.0393(\text{ST LENGTH})$	57.0

Note: Value of Equation, if ≥ 0.5 then Male otherwise Female

MS-Maxillary sinus;ST-Sella turcica,

Table 5: Comparison of intra observer observations after 1 month by using paired t-test

PARAMETERS	MEAN		P -VALUE
	OBSERVATION-1	OBSERVATION-2	
MS WIDTH (MSW)	34.610	34.575	0.957 (NS)
MS HEIGHT (MSH)	28.425	24.135	0.3304(NS)
MS INDEX (MSI)	1.503167	1.450333	0.3854(NS)
ST DEPTH (STd)	8.551667	8.601500	0.8348(NS)
ST DIAMETER (STDmt)	15.44	12.18	0.1566(NS)
ST LENGTH (STL)	9.115000	9.006667	0.7316(NS)

MS-Maxillary sinus;ST-Sella turcica, Observation-2: study done for 60 lateral cephalogram after 1 month.

p value ≤ 0.005 -statistically significant*; p value ≥ 0.005 -Not statistically significant

Conclusion

Even the parts of body are destroyed radiographs are indispensable weapons to provide justice to victim by comparing antemortem records during lifetime and postmortem radiographs. During mass disaster if all the skull bones are destroyed Maxillary sinus remain intact and Sella turcica a small saddle shaped anatomical structure has less chance of destruction during mass disaster, and this is landmark which is usually traced for cephalometric analysis. The various linear measurements in our Study revealed that all the study parameters of Maxillary sinus can be used to determine age. Discriminant function analysis revealed that maxillary sinus width had the highest accuracy in determination of gender. Sella Turcica Length and diameter can be used in determination of age. The study also revealed that the Morphology of the above anatomical landmarks vary with age, race and ethnicity. The conclusion drawn from the present study could be beneficial in forensic investigations for the identification of human victims. Further research is needed to know importance of Sella turcica and maxillary sinus in personal identification.

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