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Validation of morphometric analysis in lateral cephalogram for sex determination – a retrospective study

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ABSTRACT

The determination of sex plays a significant role in forensic medicine, especially in mass disasters. The skeleton bones are used most commonly as they are resistant to putrefaction and other factors. The most commonly used skeleton bones are Pelvis and skull bones. As the pelvis is more fragile compared to the skull, the fact that skull bone exhibits the highest sexual dimorphism, the usage of skull bone in sex determination has increased. A lateral cephalogram is ideal for the skull examination as it gives details of various anatomical points in a single radiograph, easily accessible and reproducible.

KEY-WORDS: Lateral Cephalogram, Cephalometric parameters, Identification of sex, Discriminant function analysis

MATERIALS AND METHOD

Atotalof50lateralcephalogramsweretakenoutofwhich25malesand25femalesagedbetween 13 to 31 years. The seven derived cephalometric parameters ieBasionto Anterior Nasal Spine - (Ba-ANS), Upper Facial Height - (N -ANS), Length Of Cranial Base -(Ba - N), Total Face Height - (N - M), Frontal Sinus Height - (Fs-Ht). Mastoidale to Sella-Nasion Plane - (Ma - Sn), Mastoidale to Porion - Orbitale Plane - (Ma - Fh) were used. Above mentioned cephalometric variables were transferred into an acetate sheet by tracing with the help of an x-ray film viewer using a 0.5 mm pencil. Which was further used to derive a discriminant function equation.

RESULTS

Discriminant functional analysis was carried out and a functional equation was derived. This equation was then validated for all 50 subjects. Out of seven variables, four variable ie., Ba-ANS, Ba-N, N-M, Ma-SN Plane were found to be significant in determining the sex (P <0.05 ie., Ba-ANS = 0.042, Ba-N = 0.035, N-M = 0.008, Ma-SN Plane = 0.031). For the discriminant function equation, group centroids were 0 to± 0.593; with 0 to 0.593 being males and 0 to -0.593 being females. The validation of the equation showed 76% of the males were recognized as males and 84% of females were recognized as females, with centroid score being 80%.

CONCLUSION

The lateral cephalogram and nine parameters used in this study are simple and reliable, also the deriveddiscriminantfunctionequationcanbeusedaccuratelytoidentifythesexofan individual.

CONFLICT OF INTEREST: None Declared

INTRODUCTION:

Forensic medicine plays a major role in providing scientifically proven knowledge to form authentic statements[1]. Previously the role of forensic odontology was interned to dental records, whereas at recent times skull radiography with its variables were found to evince sexual dimorphism, thus enhancing the scope of dentistry in forensic sciences. Determination of sex is the first and foremost step in forensic identification[2]. The major beneficiation in determining sex is skeletal components such as pelvis and skull[3]. As the pelvis is frangible, the skull plays a major role in sex determination.[4] For several decades, it was assumed that anthropologists studying forensics and archeological remains, weight, stature, sex as individual parameters in human biodemography. Later they were considered an intrinsic part of human biology. For the determination of sex, the osteological examination is a very reliable tool as the consolidation of dimorphic characteristics, infer the sex of the individuals. Invariably for civil and criminal purposes, human identification with birthmarks, scars, fingerprints have been recorded. However, this recognition process in mass disaster becomes inescapable[5,6]. In maxillofacial complex, frontal sinuses and mandibular ramus are considered for sex determination[7].

Skull radiographs have been found to be an unerring and unadorned method in determining the sex by their linear and angular measurements. Determination of sex from a skull found to 80-100% veracious[4,5,8,9]. Lateral cephalogram of skull found to provide far-flung information from single radiographs. As lateral cephalogram is readily available, easy to perform, cost-effective, quick result, reproducible, and easily executed in forensic examination, for much functional examination lateral cephalogram was used[10,11]. The present study was attempted to evaluate the role of lateral cephalogram in gender determination and to derive a discriminant function equation to determine the sex of individuals.

MATERIALS AND METHODS

A total of 50 lateral cephalograms collected from the study population included 25 males and 25 females, in the age range of13to31 years. Patients with malocclusion and willing for orthodontic consultation were included and patients with systemic ailments, periodontal condition, and maxillofacial trauma were excluded from the study. Ethical clearance was obtained from the ethical review committee of the institute. Lateral cephalograms of the study subject were obtained by having teeth in centric occlusion. The following seven linear cephalometric variable quantities were derived using a wide range of cephalometric bony landmarks. [(Basionto Anterior Nasal Spine - (Ba- ANS), Upper Facial Height - (N -ANS), Length Of Cranial Base -(Ba - N), Total Face Height - (N - M), Frontal Sinus Height - (Fs-Ht). Mastoidale to Sella-Nasion Plane - (Ma - Sn), Mastoidale to Porion - Orbitale Plane - (Ma - Fh)]. Above mentioned cephalometric variables were transferred into acetate sheets by tracing with the help of an x-ray film viewer using a 0.5mm pencil. The measurement linear variable was entered into an excel datasheet. The data was subsequently subjected to Statistical analysis. The discriminant functional equation was derived from a centroid point, which divided the score into male and female groups, with minimum overlap, and the accuracy of the derived function was determined.

RESULTS:

The age range of the study population was distributed from 13 – 31 years with an equal male and female cohort of 25 each.

The average dimensions and standard deviation of Seven cephalometric variables (Ba-ANS,N-ANS, Ba-N, N-M, Ma-SNPLANE, Ma-FHPLANE, Fs-Ht) are given in Table 1 showing the difference between males and females. These measurements were subjected to discriminant function analysis to check the efficacy in determining the sex

Out of the seven variables, four variables i.e.,Ba-ANS,Ba-N,N-M,Ma-SNPLANEwere found to be significant in determining the sex (P <0.05) ie., [Ba-ANS = 0.042, Ba-N = 0.035, N-M = 0.008, Ma-SN Plane = 0.031)] which is shown in the Table2.
A discriminant function equation was derived using the coefficient of cephalometric variables, D = (Ba-ANS x 0.642) – (N-ANS x 0.196) – (Ba-N x 0.308) + (N-M x 0.781) + (Ma-SNPLANE x 0.441) – (Ma-FH PLANE x 0.761) + (FS-Ht x 0.156)
Functions at group centroids were 0 to ± 0.593, with 0 to 0.593 being males and 0 to - 0.593 being females. The validity of derived discriminant function was then assessed among the 50 study subjects, the results showed 76% of the males were recognized as males and 84% of females were recognized as females, with centroid score being 86%(Table.3).

DISCUSSION

Sexual dimorphism has been of great interest for many decades. For the determination of sex in forensic sciences, key analysis is done by constructing the biological profile of the human skeleton.[11,12] Reason for using human skeleton bone is it has extraordinary resistance to putrefaction and effects of external agents.[12] Pelvic bone is considered as the gold standard for sex determination in forensic, followed by cephalograms, as they are standardized and easily reproducible.

The study this subducted later,al cephalograms that were taken for investigative purposes. In Lateral cephalograms lateral cephaloan grams were selected, which consisted of 25 an from each sex. Lateral cephalograms have advantage as they are inherent or both investigation and research purposes. Cephalograms are found to have nherent uniform magnification, ut d Patil et al [16] stated in their study that, this magnification is not a major drawback if it is common for all parameters and the subjects.
Based on the previous shreds of evidence, seven cephalometric variables are used in this study. The age lower limit was at 13 years and the upper limit at 31 years. In the present study, it was noted that Ba-ANS, Ba-N, N-M, Ma-SN plane are the functional variables in determination of sex(table 2) which was consistent with the findings of Pavia and Patil et al[16,17]. The other variables N-ANS, Ma-FH plane, FS-HT (table 2) were the least determinants, as also reported by Hsiao et al 1996, but not congruous with findings of Patil et al (2005)[15,16].
Ba-ANS (depth of the face) was found to be one of the major variables in the present study, which was found to be inconsistent with Kanchan and Modi[16] et al 2005, V.G Naikmasur[19] et al 2010, Mahalaxmi[18] et al 2013, Almas Binnal[10] et al 2012.
FS-Ht was found to be the least dependable variable in this study which was dependable with Almas Binnal[10]etal2013 and inconsistent with Camargo[20] et al 2007, Veyre gouley[4] et al (2008) Mahalaxmi[18] et al(2013), Sowmya Verma[21] et al (2014), Sai Kiran[22] et al2014.
In addition, N-ANS was also, not a strong determinant in the study, and this was consistent with the study conducted by Almas Binnal[10] et al 2013 and inconsistent with Ruchi Mathur[23] et al2015
Chang[24] et al 1993 and Rogers[25] et al 2005 stated that though craniofacial growth pattern is the same for both sexes, there is one for sexual dimorphism is a result of early attainment of skeletal maturity in females compared to males. They also stated that sex differences occur due to late-going structures of the skull, such as lower facial height, facial depth, and mastoid process, whereas the cranial base and upper face are middle growing regions in which some sexual differences may be evident. In the present study, Ba-ANS (depth of face) was found to be a major contributor to sexual dimorphism, which could be due to geographic diversity.
The discriminant functional equation derived in this study was found to show 86% accuracy in distinguishing male and female subjects, with an efficacy of 76% in males and 84% in females. Franklin[26] et al in his study reported 77 to 80% accuracy in sexual determination using eight cephalometric parameters. Almas Binnal[10] et al. reported 86% accuracy in gender

determination using nine variables. Mahalaxmi[18] et al in 2013 conducted a study using 10 cephalometric variables and claimed 73% accuracy, whereas Patil and Modi[16] et al showed 99% accuracy with 10 cephalometric variables.
These differences in the findings may be due to various factors such as the age of the study group, varying predictors, different population groups, and magnification factors.

CONCLUSION:
The determination of sex using lateral cephalogram needs population-specific assessment as it varies with population genetics. Also, the skeletal structure of human beings transforms due to numerous environmental factors. Hence fixed standards of assessment must be followed for the individual population. The findings in the present study corroborate the role of lateral cephalogram in sex determination for the early adulthood phase. However further studies should be carried out to assess the role of lateral cephalogram and cephalometric parameters in gender determination among the different populations of the world and for a wider age range.

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Table 1: Group statistics for males and females

	Male (n=25)		Female (n=25)		Total (n=50)	
	Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*
Ba-ANS	9.880	0.814	9.388	0.850	9.634	0.861
N-ANS	4.952	0.391	4.740	0.497	4.846	0.455
Ba-N	10.240	0.990	9.672	0.851	9.956	0.958
N-M	11.476	0.961	10.768	0.857	11.122	0.970
Ma-SNPLANE	4.320	0.535	3.996	0.496	4.158	0.536
Ma-FH PLANE	2.408	0.644	2.532	0.554	2.470	0.598
FS-Ht	2.816	0.744	2.616	0.560	2.716	0.659

Table 1: Discriminant function analysis between males and females

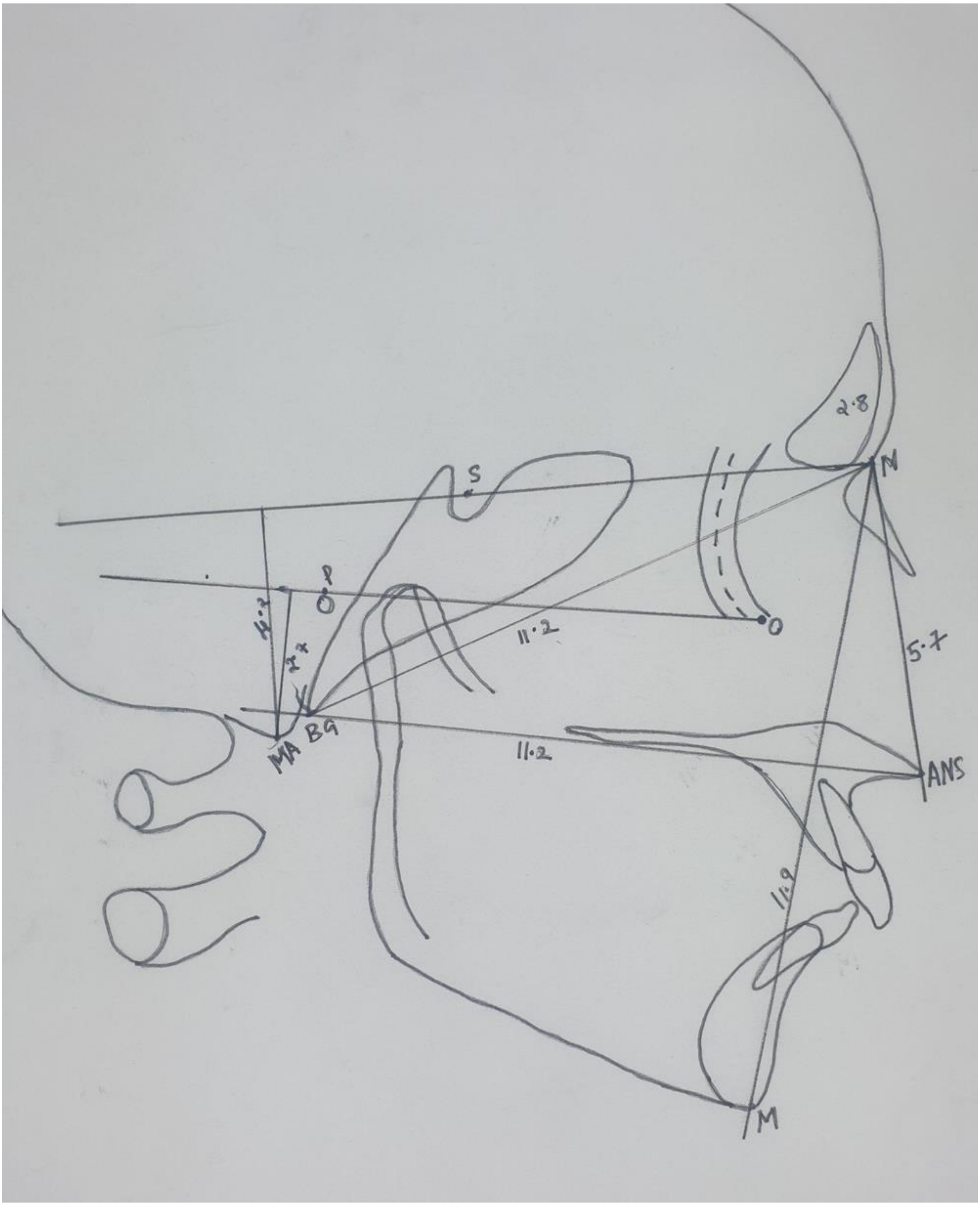
	Wilks' Lambda	F	df1	df2	Sig.
Ba-ANS	0.917	4.366	1	48	0.042
N-ANS	0.945	2.808	1	48	0.100
Ba-N	0.910	4.729	1	48	0.035
N-M	0.864	7.557	1	48	0.008
Ma-SNPLANE	0.907	4.925	1	48	0.031
Ma-FH PLANE	0.989	0.532	1	48	0.469

FS-Ht	0.977	1.153	1	48	0.288

Table 3: Accuracy of discriminant function for sex determination

			Predicted Group Membership		
		Sex	Male	Female	Total
Original	Count	Male	19	6	25
		Female	4	21	25
	%	Male	76.0	24.0	100.0
		Female	16.0	84.0	100.0

a. 80.0% of original grouped cases correctly classified.



Lateral Cephalogram showing angular measurements