Evaluation of the correlation between Cephalometric parameters and sex prediction in West Uttar Pradesh: A Cross-Sectional Study

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ABSTRACT-

As the consolidation of dimorphic characteristics concludes the sex of the individual, osteological examination is a very reliable tool for determining the sex of the individual. This research was carried out using lateral cephalograms and an index was formed, which could be considered as a reliable sex determinant in forensic applications.

Materials and Methods: This study was performed on samples of west Uttar Pradesh population. Fifty individuals, whose age ranged between 25 and 40 years, were taken (25 male subjects and 25 female subjects). All conventional hard tissue cephalometric variables were compared, subjected to statistical analysis and tested for significance.

Results: Out of a total of 72 variables tested, only six variables showed statistical significance. These six variables were then subjected to discriminant function analysis to evaluate the effectiveness of each variable in predicting the sex of an individual. Individually, the Y-axis showed the highest sex determining dependability of 76% followed by a facial angle showing 74% dependability. On the other hand, lower facial height angle (68%), mandibular plane angle (68%), Pog to N perpendicular (66%), and mandibular length Go-Gn (60%) showed lowest consistency. With regard to individual sex, the Y-axis shown the highest reliability at 76%, followed by a facial angle at 74%.

Conclusion: From this study, it is evident that cephalometric parameters are reliable in determining the sex of an individual. All the statistically significant data showed high and acceptable percentage of reliability. This proves that the chosen variables can be used for West Uttar Pradesh population to determine the sex of individuals of interest.

Keywords: Sex Determination, Cephalograms, Hard Tissue

Introduction:

There are multiple factors that differentiate individuals across various species, including their behavior, physical build, vocalizations, habitat, and lifestyle.[1] Gender differentiation among species can be established through sexual dimorphic traits.[2] These factors are essential in forensic science for maintaining records and identifying perpetrators.

Identity is defined by a set of characteristics that uniquely identify a person, such as birthmarks, scars, and fingerprints.[3] However, these identifiers are not applicable when only skeletal remains are available. In scenarios involving mass disasters or archaeological sites, skeletal remains are crucial for establishing identity. Sex determination from skeletal remains can be achieved through both metric and nonmetric (morphological) methods, with the pelvic bone and skull being the primary bones used for this purpose.[4] Notably, prepubertal female skulls are generally smoother and more gracile compared to

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the more robust male skulls, which feature pronounced supraorbital ridges and larger muscular attachment areas.[5] Other skeletal features, including the frontal sinus, maxillary sinus, and mandibular ramus, also exhibit sexual dimorphism.[5]

Research indicates that sex estimation from skulls has an accuracy rate ranging from 80% to 100%.[6] In a study conducted by Badam et al., involving 100 individuals, skull examination was found to be highly accurate for sex determination.[7] Similarly, Divakar et al. performed a discriminant function analysis on lateral cephalograms and validated this method's reliability for gender determination.[8]

The present study utilizes lateral cephalograms of the skull to determine sex due to their ability to provide extensive information from a single radiograph. Functional analyses were performed on the lateral cephalograms, concentrating on the maximum number of parameters that can be evaluated in the facial bones and mandible. The primary research question addressed the reliability of these parameters in accurately determining an individual's sex based on facial bone and mandible assessments.

The study's main objective was to assess the reliability of using various parameters from lateral cephalograms for sex determination. The null hypothesis posited that the parameters obtained from lateral cephalograms do not significantly differ in their efficacy for determining sex based on facial bone and mandible evaluations.

Materials And Methods

This study was conducted using samples from the West Uttar Pradesh population. It was a cross-sectional analysis utilizing pre-treatment lateral cephalograms from patients seeking orthodontic care at our institution. With a 95% confidence interval, a proportion percentage of 10%, and a margin of error of 8.3%, the sample size was determined to be 50.

Out of 150 screened patients, 50 individuals were selected for the study, comprising 24 males and 26 females, all aged between 15 and 25 years.

The study was based on lateral cephalograms of individuals receiving orthodontic treatment at the Department of Orthodontics and Facial Orthopedics, Institute of Dental Sciences and Technologies.

Inclusion criteria for this study were: willingness to participate, no history of facial trauma, and no prior cosmetic surgery or orthodontic treatment. Exclusion criteria included: unwillingness to participate, history of surgery or orthodontic treatment, medical complications, previous maxillofacial trauma, and pregnancy (to avoid radiation exposure). A total of 72 cephalometric parameters, including both linear and angular measurements, were assessed. Six analyses—Down's, Tweed's, Steiner, Jarabak, McNamara, and Ricketts—were performed using the "oneceph" mobile application. This application provides precise linear and angular measurements after anatomical landmarks are marked.

Cephalometric analysis was conducted by three trained individuals under the supervision of an experienced orthodontist. Both intra-observer and inter-observer errors were evaluated. Intra-observer error was assessed by having 10 randomly selected patients measured twice, with at least a two-week interval between measurements. Inter-observer error was assessed by a fourth trained investigator measuring the same patients twice, and the differences were calculated.

Statistical analysis was performed on the cephalometric variables, with significance tested using the t-test and a p-value of <0.05 considered statistically significant.

Results

All the 72 variables, linear as well as angular, were analysed with 'individual t-test' for statistical significance. Out of 72, only 6 variables showed statistical significance. These 6 variables were the subjected to discriminant function analysis to evaluate the effectiveness of these variables for predicting the sex of an individual. Method error was determined using Intra class Correlation Coefficient and was found to be high (0.89)

A discriminant model was created for each variable that showed statistical significance where separate formulas were used for males and females were used to check the accuracy and reliability of these parameters. Depending upon the values obtained the specific formula, the sex of the patient was determined. Based on the accuracy, the predictability of the variables was calculated.

Assessing the predictability scores, Y-axis showed the highest sex determining dependability of 76% followed by facial angle showing 74% dependability. On the other hand, lower facial height angle (68%), mandibular plane angle (68%), Pog to N perpendicular (66%), and mandibular length Go-Gn (60%) showed the respective percentage of dependability.

Table 1

Comparison of various cephalometric parameters among males and females

Variable	Male (n=24)			Female (n=26)			p-value
	Mean	SD	SEM	Mean	SD	SEM	
Skeletal							
Facial angle	84.05	5.71	1.17	89.27	6.16	1.21	0.003*
Angle of convexity	8.56	8.81	1.80	7.17	9.24	1.81	0.591
Mandibular plane angle	22.55	8.24	1.68	17.74	7.07	1.39	0.031*
AB plane	-9.13	5.20	1.06	-8.05	5.11	1.00	0.461
Y axis	61.23	6.02	1.23	55.99	5.45	1.07	0.002*
Cant of occlusal plane	11.55	6.56	1.34	20.37	67.84	13.30	0.529
IIA	122.25	11.09	2.26	118.05	12.94	2.54	0.226
Incisor Occlusal plane angle	6.87	72.95	14.89	11.12	71.70	14.06	0.836
Incisor Mandibular plane angle	8.39	8.85	1.81	9.31	11.32	2.22	0.752
Upper incisor protrusion	7.94	3.04	0.63	7.63	3.20	0.64	0.735
SNA	83.24	3.94	0.81	85.15	4.96	0.97	0.139
SNB	78.70	5.44	1.11	80.86	3.88	0.76	0.110
ANB	4.93	3.56	0.73	4.29	3.52	0.69	0.525
SND	75.91	5.05	1.03	78.16	3.58	0.70	0.074
PogNB	1.70	1.64	0.33	1.40	1.85	0.38	0.555
SNOP	16.30	7.04	1.44	14.74	4.11	0.81	0.339
SNMP	26.68	8.61	1.76	24.39	6.02	1.18	0.280
UI NA Angular	26.56	10.89	2.22	31.13	8.82	1.73	0.108
UI NA linear	5.28	3.79	0.77	5.78	3.38	0.66	0.623
LI NB Angular	27.02	6.73	1.37	27.09	8.61	1.69	0.974
LI NB linear	5.33	2.11	0.43	5.29	3.22	0.63	0.963
IIA	109.90	58.30	13.04	118.06	13.55	2.83	0.518
Upper lip	4.41	1.37	0.28	4.38	1.67	0.33	0.950
lower lip	4.05	2.59	0.53	3.52	2.27	0.45	0.443
FMPA	26.16	8.34	1.74	22.56	7.79	1.53	0.125
FMIA	58.03	9.58	1.96	62.49	13.09	2.57	0.178
IMPA	96.05	9.58	1.96	94.95	15.42	3.03	0.767
Saddle angle	122.92	7.35	1.50	162.79	194.84	38.21	0.322
Articular angle	142.33	10.65	2.17	141.09	7.81	1.53	0.640
Gonial angle Ar-Go-Me	124.43	8.26	1.69	121.35	9.34	1.83	0.224
Upper Gonial angle Ar-Go-N	54.11	7.24	1.48	53.81	4.81	0.94	0.862
Lower gonial angle Go-N-Me	69.89	6.71	1.37	67.14	6.13	1.20	0.136
Sum of angles	389.68	9.04	1.84	386.77	6.15	1.21	0.186
Anterior cranial base length S-N	63.27	3.30	0.67	62.49	4.63	0.91	0.501
Posterior cranial base length S-Ar	33.73	5.15	1.05	31.76	4.40	0.86	0.150
Ramus height Ar-Go	39.25	6.98	1.42	40.62	4.46	0.88	0.411
Mandible body length Go-Gn	65.43	3.77	0.77	68.25	4.84	0.95	0.027*
Anterior facial height N-Me	101.06	10.59	2.16	97.48	7.02	1.38	0.162
Posterior facial height S-Go	68.90	8.05	1.64	68.16	7.16	1.40	0.734
PFH:AFH	0.69	0.08	0.02	0.70	0.06	0.01	0.470
UI-SN angular	109.68	11.49	2.35	102.35	67.40	13.22	0.601
UI-N-Pg linear	10.34	4.24	0.87	9.66	4.75	0.93	0.595
Li-N-Pg linear	4.20	2.86	0.58	4.17	4.31	0.85	0.970
Facial Axis angle	94.53	7.91	1.61	95.07	5.35	1.05	0.777
Mandibular plane angle	22.17	8.40	1.72	16.92	6.36	1.25	0.016
Facial taper angle	72.93	6.30	1.29	73.83	6.09	1.19	0.611
Lower facial height angle	41.59	8.79	1.79	36.66	5.05	0.99	0.018*
Palatal angle	-0.15	3.83	0.78	-2.35	4.94	0.97	0.086
Mandibular arc angle	35.29	10.79	2.25	36.42	8.71	1.78	0.693
Facial angle	38.94	119.63	24.42	4.16	151.76	29.76	0.375
Maxillary convexity	4.05	3.08	0.63	2.47	3.32	0.65	0.088
Lower incisor Protrusion	1.54	1.68	0.34	2.25	3.16	0.62	0.331
Lower incisor Protrusion angle	21.64	7.88	1.61	24.10	7.07	1.39	0.250
Lower lip protrusion	1.12	3.50	0.71	-0.01	3.69	0.72	0.276
IIA	122.29	10.74	2.19	118.17	13.36	2.62	0.238
Upper molar position	16.25	9.11	1.90	14.86	3.98	0.78	0.483
Nasolabial angle	108.14	13.01	2.66	105.37	14.47	2.84	0.481
Cant of upper lip	7.85	11.95	2.44	12.44	10.19	2.00	0.149
Point A to N perpendicular	-1.39	4.06	0.83	0.80	3.87	0.76	0.056
Co-point A	78.96	5.26	1.07	80.14	6.24	1.22	0.477
Co-gnathion	98.72	6.45	1.32	101.51	6.64	1.30	0.139
Maxillo Mandibular differential	19.95	4.01	0.84	21.37	5.14	1.01	0.292
ANS-Me	57.97	7.62	1.56	56.02	6.63	1.30	0.338
Facial Axis angle	4.63	7.81	1.59	5.43	4.95	0.97	0.664
Mandibular plane angle	24.50	9.04	1.85	19.82	8.24	1.65	0.064
Pog to N perpendicular	-10.23	10.22	2.09	-4.27	10.52	2.06	0.048*
Upper 1 to point A	5.24	2.50	0.51	6.55	3.30	0.65	0.122
Lower incisor Protrusion	1.38	1.70	0.35	2.25	3.16	0.62	0.237
Upper pharynx	13.73	3.91	0.80	14.49	4.41	0.87	0.520
Lower pharynx	11.18	2.85	0.58	12.29	3.40	0.67	0.218

Discussion

Determining sex is crucial for constructing a biological profile of human remains. Sexual dimorphism in cranial size and shape can vary significantly over short periods and among different populations due to factors such as genetics, environment, and lifestyle. Traditional visual assessments of sexual dimorphism are often subjective and prone to observer variability. In contrast, measurement-based techniques like cephalometry offer superior accuracy and reliability for sex determination from skulls.[6]

This study aimed to evaluate the reliability of various parameters derived from lateral cephalograms for sex determination within the Western Uttar Pradesh population.

Previous research has demonstrated the effectiveness of cephalometric analysis in sex determination. For instance, a study by Missier et al. involving 250 individuals from Chennai achieved an overall reliability of 96% using ninety-nine selected parameters.[2] Hsiao et al. studied 100 Taiwanese children, recording 22 variables, of which 9 were statistically significant. Discriminant functional analysis of these variables yielded a 95% accuracy rate in gender prediction.[9] Patil and Mody, examining 150 individuals from Central India, found that ten variables provided 99% reliability in gender determination through discriminant function analysis.[10] In a large-scale study conducted by Devang Divakar et al. in Coorg, India, involving 616 lateral cephalograms and 24 variables, only one variable proved to be a gender predictor with 100% accuracy.[8]

Our study considered 72 cephalometric variables for sex determination. Each variable was given equal weight, resulting in reliable and robust findings. Future research with larger sample sizes could further validate these observations and enhance the technique's applicability as a gender-determining tool.

Forensic odontology remains a vital field within forensic science but requires more extensive and rigorous research to solidify its methods and practices. The current research landscape is limited, and addressing these gaps through systematic and collaborative efforts is crucial for advancing the field. To establish forensic odontology as a distinct specialty, further mainstream research is necessary. Anthropometric studies conducted in specific geographic regions cannot provide generalized information for populations of varying ethnicities due to differences in skeletal growth patterns, dietary habits, genetic makeup, and climate.[2]

Additionally, the relatively small sample size in this study limits the ability to draw definitive conclusions regarding the study's objectives. The technique may also be less applicable in cases where the facial and cranial skeletons are severely damaged, disfigured, or crushed beyond the scope of radiographic analysis. However, in scenarios such as accidents, homicides, floods, tsunamis, and earthquakes, lateral cephalograms obtained from exposed skulls can be used to determine sex using the proposed technique.

Conclusion

The study concludes that sexual dimorphism can be effectively assessed using lateral cephalometric analysis. The findings confirm the utility of lateral cephalograms and six key cephalometric parameters in sex identification. Among these parameters, the Y-axis exhibited the highest reliability at 76%, followed by the facial angle at 74%. Other parameters, including the lower facial height angle and mandibular plane angle (both 68%), Pog to N perpendicular (66%), and mandibular length Go-Gn (60%), also demonstrated notable reliability. Considering the influence of environmental factors on the skeletal structure, it is recommended that specific assessment standards be developed for different populations. Further research involving larger sample sizes and diverse age groups is suggested to validate the reliability of the discriminant method across various populations.

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