ISSN : 1001-1781

Journal of Clinical Otorhinolaryngology, Head, and Neck Surgery

DETERMINATION OF THE SEX IN THE POPULATION OF SALEM DISTRICT USING VARIOUS CEPHALOMETRIC MEASUREMENTS - A CROSS SECTIONAL STUDY

RUNNING TITLE: Sex Determination using Cephalometrics

TYPE OF ARTICLE: ORIGINAL ARTICLE

Kruthika M*[a], R Madhavan Nirmal[b], B Sekar, Shankar[c], Syed Khalid Altaf[d], Nandhini Dhanasekaran[e]

NAME OF DEPARTMENT:

a. Kruthika M, M.D.S, Reader, Department of Pedodontics & Preventive dentistry, Vivekananda Dental College for Women, Tiruchengode.

b. R Madhavan Nirmal, M.D.S, Professor, Department of Oral and Maxillofacial Pathology, Rajah Muthiah Dental College and Hospital, Chidambaram

c. B Sekar, M.D.S, Professor, Department of Oral and Maxillofacial Pathology, Vinayaka Mission Sankarachariyar dental college, Salem

d. Shankar S, M.D.S, Professor, Department of Public Health Dentistry, Vivekananda Dental College for Women, Tiruchengode.

e. Syed Khalid Altaf, M.D.S, Professor, Department of Orthodontics, Vivekananda Dental College for Women, Tiruchengode.

f. Nandhini Dhanasekaran-undergraduate Student, Vivekanandha Dental College for Women, Namakkal.

CORRESPONDING AUTHOR:

NAME: KRUTHIKA.M

ADDRESS: Reader, Department of Pedodontics and Preventive Dentistry, Vivekanandha Dental College for Women, Elayampalayam, Tiruchengode, Namakkal district, Tamilnadu, India. 637205

E-mail –smilekruthika@gmail.com

Abstract

Background: During medicolegal situation, mass disasters or any conditions requiring forensic identification, the skull bones can be exposed to radiation to obtain lateral cephalometric radiographs. . The landmarks present in the radiographs can be used to determine the sex of the individual after measurement**. Aim:** The aim of our study is to to develop a formula to identify sex of the population of Salem district.**Materials and methods:** A cross-

sectional study was conducted using 100 digital lateral cephalometric radiographs of 6 to 30 years old population of Salem district. All the lateral cephalometric radiographs will be traced and analyzed digitally by using a standardized Carestream CS8100 SC software. **Result:**The mean values of males higher for variables such as AO (A to Occlusal Plane), BO (B to Occlusal Plane) ,Chin thickness (Pog' to N-B) than females. This study showed a overall accuracy of 92.6% for determination of sex using lateral cephalometric radiographs. **Conclusion:** Thisstudy was able to develop formula for gender identification in Salem population.

Key words; Forensic Science,Forensic Anthropology, Medicolegal Situation, Cephalometric Radiograph

Introduction

Forensic science is the branch of science which deals with the investigation of human remnants, followed by generation of scientific evidence and producing it to the court of law.[1] Forensic odontology and forensic anthropology are the two main displines of forensic science which deals with the structures of craniofacial region. The teeth and bones present in the maxillofacial region are the most resistant structures among other structures of the body.[2,3] Especially the bony structures of the skull display a variety of landmarks which can be taken as reference points for investigation of human remnants.[4] The identification of human remnants is utmost important in in case of medicolegal situations, mass disasters, terrorist attacks and war situations.[4,5,6]

The identification of sex of a human remnant is the basic step in the hierarchy of recognizing an individual.[5,7] Even though pelvis bone seems to be more accurate for determination of sex of an individual yet skull bone can be used for identification of gender when the remnants of pelvis bone are not available.[4,8,9] The accuracy of determination of sex of an individual is 100% when complete skeleton is present, 98% when evaluated with skull and pelvis bone and 92% when only skull bone is available. The skull seems to the second bony region of the body for determination of sex of an individual after pelvis bone.[4,9,10] Thus, sex determination using skull bones can be used as alternative method in the forensic identification procedure.[4]

The two methods in determination of sex of individual are morphological and morphometric. Morphological methods can lead to inter-investigator variations.[4,9,11] This variation can result inappropriate identification of sex of an individual. The morphometric method is generalized, can be applied to every member of a particular population and helpful in precise identification. The morphometric method uses various landmarks for measurement.

The radiographs such as orthopantomogram and cephalograms can be used to visualize the landmarks of the skull. The cephalometric radiograph reveals wide range of soft tissue and hard tissue landmarks for measurement.[6,11] The cephalometric radiographs are also available easily for the study purposes because, the lateral cephalograms are the routinely prescribed radiographs for the diagnosis of various skeletal deformities. So, the evaluation of various linear and angular measurements using lateral cephalometric radiograph for this study can be performed without the exposure of human participants into radiation.

During medicolegal situation, mass disasters or any conditions requiring forensic identification, the skull bones can be exposed to radiation to obtain lateral cephalometric radiographs. The landmarks present in the radiographs can be used to determine the sex of the individual after measurement. This method is the most convenient, accurate and easier approach of identifying sex of an individual.[11] Even though, there are many previous studies which derived formula for determination of sex, the measurements vary for different population. Hence, reference values for each population are essential. These reference values can be used to derive formula for every population which helps in accurate determination of sex of individual. So, the aim of the study is to develop a formula to identify sex of the population of Salem district.

Materials and method

A total of 100 samples were included in the cross-sectional study. Among them --- males and females. The age group of the study population was between 6 to 30 years. The digital lateral cephalometric radiograph of the study population was collected from the Salem district which was taken for diagnostic purposes before orthodontic treatment, orthognathic surgeries, developmental deformities and other skeletal deformities.

The inclusion criteria of the study were lateral cephalometric radiograph with good clarity and absence of artifacts and patients belonging to the age group of 6-30 years. The exclusion criteria of the study were lateral cephalometric radiograph which showed missing teeth, syndromes, cleft palate, cleft lip, congenital anomalies, developmental disorders of teeth or jaw, patient had an history of orthodontic treatment and orthognathic surgery, cases with history of head and neck injury, patients undergone surgery in the head and neck region and radiographs showing craniofacial pathologies.

All the lateral cephalometric radiographs were traced and analyzed digitally using a standardized Carestream CS8100 SC software.

A total of 10 cephalometric points such as Point A (A), Nasion (N), Point B (B), Condylion (Co), Menton (Me), Gonion (Go), Anterior nasal spine (ANS), Posterior nasal spine (PNS), Soft tissue pogonion (Pog’), Labialis superior (Ls) and planes including N-B plane (formed between point N and point B), Mandibular plane (formed between Me and Go), Palatal plane ((formed between ANS and PNS), Occlusal plane were used to construct following linear measurements:

1. AO (A to Occlusal Plane)
2. BO (B to Occlusal Plane)
3. Chin thickness (Pog' to N-B)
4. Upper lip thickness (Ls to N-B)
5. Anterior facial height (Me to Palatal Plane)
6. Posterior facial height (Co to Mandibular Plane)

Statistical analysis:

Statistical analysis was performed using the Statistical Package for the Social Science (SPSS) version 17.0 software. Descriptive statistics (mean and standard deviation) was computed for each variable and Student's t-test was used to determine if statistically significant differences existed between the sexes. The level of significance was kept at $p \leq 0.05$.

All the predictor variables were subjected to stepwise discriminant function analysis, which has the potential to optimally separate the sexes; further the statistical significance was assessed using Wilks' lambda. The variables having the higher discriminant function coefficient were included in the discriminant function for developing the formula.

Di = K + di1z1 + di2z2+ …….+ dipzp

where Di is the discriminant function score, di is the discriminant function coefficient, z is the score of the predictor variable and K the discriminant function constant.

Results

The intra-observer reliability calculated during the second examination after 2 months revealed the ICC value to be .965. Hence the measurements made at two different points showed negligible difference. Therefore, the initial measurements were taken into consideration for calculation.

Table 1 depicts the students T-test for the comparison of variables (Upper lip thickness, AFH, PFH, AO, BO, chin thickness) between male and female. The mean values of males were significantly higher for variables such as AO (A to Occlusal Plane) ($p = 0.089$), BO (B to Occlusal Plane) ($p = 0.082$), Chin thickness (Pog' to N-B) ($p = 0.032$)than females.

Table 2 shows the accuracy of the discriminant function coefficient for all the predictor variables which were included in this study, from which the highest accurate values were included for the generation of the discriminant function.

The discriminant analysis produced the best discriminant functions and the predictor variables included in the functions were AO (A to Occlusal Plane), BO (B to Occlusal Plane), Chin thickness (Pog' to N-B), Upper lip thickness (Ls to N-B), Anterior facial height (Me to Palatal Plane), Posterior facial height (Co to Mandibular Plane), based on the greatest univariate discriminant coefficient. Before the formula was calculated with the greatest univariate discriminant coefficient AO (0.56), the predictor variables were subjected to a test of significance using Wilks' lambda. It was found that the entire assigned predictor variables showed statistical significance at $p < 0.05$ (Table 2).

The best discriminant function was

F= - 10.479+(0.56×AO)

From the stepwise discriminant analysis, the group centroid was also generated for both the sexes. A group centroid is the mean discriminant score for each sex. A cut-off point, which separates one sex from the other, is the average of the two centroids; a smaller value than this is considered as a female and vice versa. The cut-off point between the sexes was -0.0305. The male group centroid was 0.305 and the female group centroid was -0.366. Raw coefficients, the discriminant function coefficients, were used to calculate the discriminant score.

The value obtained using discriminant function for the measurements of males and females is calculated respectively. Hence it shows that this discriminant function formula can accurately identify sexual dimorphism in this population.

To assess whether it is possible to generate accurate sex models from the data collected for this study, discriminant functions were calculated and tested using cross-validation. This was performed using SPSS software and the leave-one-out method was chosen to calculate the cross-validation error rate (Table 3). The discriminant function used in the present study describes the optimal separation between the sexes and shows that there are significant variations between them, and it is substantiated by classification accuracy of functions provided in Table 3. Hence, the original grouped cases correctly classified were 92.6%.

Table 1 – students T-test for the comparison of variables (Upper lip thickness, AFH, PFH, AO, BO, chin thickness**) between male and female.**

Variable	**Male (1)** **μ ± SD**	**Female(2)** **μ ± SD**	**T-test**	**Significance**
AO	19.228± 1.9982	18.037 1.466	3.346	0.039*
BO	17.293 3.231	16.863 2.412	0.742	0.082
Chin thickness	11.494 3.108	11.370 1.861	0.238	0.032*
Upper lip thickness	22.291 3.050	21.007 3.199	2.052	0.795
Anterior facial height	56.672 4.682	53.989 3.762	3.119	0.191
Posterior facial height	36. 748 3.037	35.128 3.022	2.664	0.872

*- Statistically Significant

Table 2 - Wilks Lambda to test the significance of predictor variables.

Test of Function(s)	**Wilks' Lambda**	**Chi-square**	**Df**	**Sig.**
1	.898	10.417	1	.001***

	Function
	1
AO (A to occlusal plane)	0.561
(Constant)	-10.479

*****-**Highly statistically significant

Table 3 – Shows the canonical discriminant and function coefficient.

Table 4 – Shows the group centroids.

Sex	Function 1
Male	0.305
Female	-0.366

Table 5 - Depicts the classification accuracy check using cross validation

		Sex	**Predicted Group Membership**		**Total**
			Male	**Female**	
Original	Count	Male	52	2	54
		Female	5	40	45
	percentage	Male	96.3	3.7	100
		Female	11.1	88.9	100
Cross-validated	Count	Male	52	2	54
		Female	5	40	45
	percentage	Male	96.3	3.7	100
		Female	11.1	88.9	100

a. 92.6% of original grouped cases correctly classified.

b. Cross validation is done only for those cases in the analysis. In cross validation, each case is classified by the functions derived from all cases other than that case.

c. 92.6% of cross-validated grouped cases correctly classified.

Discussion

Human identification from remnants has been researched since long time to develop specific methods to establish identity of a person.[4,12] The human remnants can be tooth, bone, mucous

secretions such as saliva and blood etc. among these remnants the teeth and bone are the most resistant and available in many situations.[2,3] The identification of gender and chronological age is the basic identity of an individual. This study focused on the determination of sex by lateral cephalometric radiograph.

Although pelvic bones are most reliable for determination of sex, skull bones also display many features for determination of sex.[4,8,9] The determination of sex using skull bone can be employed as alternative method when pelvic bones are not available. The development of alternative method can act as another source of obtaining information during forensic evaluation. The evaluation of skull using lateral cephalometric radiograph for determination of sex is the simpler and precise method as compared to other methods.

The accuracy of determining sex using morphological or anthropometric methods ranges from 77% to 92.5%. Although there are several studies based on determination of sex using lateral cephalometric radiographs, the formula generated cannot be used for all the population because of diversity in food, cultural practices, climatic conditions among different populations.[4] This study was aimed to develop formula for identification of sex in Salem population.

Previous study done by Darshan Devang Divakar et al.[4] showed the mean linear measurements of males were greater than females which was similar to the results of our study and the overall reliability of the same study was 100% which was greater than our study. The results of Rawad Qaqet al.[12] overall accuracy was 82.4% for both females and males which was lower than our study with 92.6% accuracy.

Also, there were some limitations in the study, such as the sample size was less, the formula generated cannot be used for all the population, this method cannot be employed when the skull bones are damaged. The advantages of the study were this study was able to develop formula for gender identification and formulated an alternative method for gender determination in the specific population.

Conclusion

This study showed a overall accuracy of 92.6% for determination of sex using parameters such as AO (A to Occlusal Plane), BO (B to Occlusal Plane), Chin thickness (Pog' to N-B), Upper lip thickness (Ls to N-B), Anterior facial height (Me to Palatal Plane), Posterior facial height (Co to Mandibular Plane) constructed in lateral cephalometric radiograph. This study can be helpful in forensic identification procedure in case of flood, medicolegal situations, earthquakes, terrorist attacks and war situations

Acknowledgment: the authors want to thank the dental students who participated in the study.

Presentation: NIL

Source(s) of support and funding: NIL

Conflicts of interest: The manuscript has been read by all the authors and it is believed that the manuscript represents honest work.There are no conflicts of interest.

Consent form: OBTAINED

Ethical approval: OBTAINED

References

1. Shen M, Vieira DN. Forensic science: defending justice. Forensic sciences research. 2016 Nov 25;1(1):1-2.
2. Shankar S, Anuthama K, Kruthika M, Kumar VS, Ramesh K, Jaheerdeen A, Yasin MM. Identifying sexual dimorphism in a paediatric South Indian population using stepwise discriminant function analysis. Journal of Forensic and Legal Medicine. 2013 Aug 1;20(6):752-6.
3. Salkar PS, Thakare AE, Fating C, Deoghare A, Fuladi T. Estimation and Determination of Stature and Gender of Adult Chhattisgarh Population using Digital Lateral Cephalograms. International Journal of Forensic Odontology. 2020 Jul 1;5(2):51.
4. Divakar DD, John J, Al Kheraif AA, Mavinapalla S, Ramakrishnaiah R, Vellappally S, Hashem MI, Dalati MH, Durgesh BH, Safadi RA, Anil S. Sex determination using discriminant function analysis in Indigenous (Kurubas) children and adolescents of Coorg, Karnataka, India: A lateral cephalometric study. Saudi journal of biological sciences. 2016 Nov 1;23(6):782-8.
5. de Oliveira FT, Soares MQ, Sarmento VA, Rubira CM, Lauris JR, Rubira-Bullen IR. Mandibular ramus length as an indicator of chronological age and sex. International journal of legal medicine. 2015 Jan;129:195-201.
6. Khaitan T, Kabiraj A, Ginjupally U, Jain R. Cephalometric analysis for gender determination using maxillary sinus index: a novel dimension in personal identification. International journal of dentistry. 2017 Mar 8;2017.
7. Rajkumar C, Daniel MJ, Srinivasan S, Jimsha VK. Gender prediction from digital lateral cephalogram-a preliminary study. Annals of Dental Specialty. 2017 Apr 1;5(2):48-51.
8. Motawei SM, Helaly A, Aboelmaaty WM, Elmahdy K. Mandibular Ramus linear measurements as an Indicator of Chronological Age and Sex in Egyptian Population. Egyptian Dental Journal. 2018 Oct 1;64(4-October (Oral Medicine, X-Ray, Oral Biology & Oral Pathology)):3287-94.
9. Mathur A, Sande A, Risbud M, Ramdrug P, Ashwinirani SR. Determination of sex by discriminant function analysis of lateral radiographic cephalometry using angular, linear and proportional cephalometric variables in Western Maharashtrian population. Journal of Oral Medicine, Oral Surgery, Oral Pathology and Oral Radiology. 2017;3(3):153-7.
10. Badam RK, Manjunath M, Rani MS. Determination of sex by discriminant function analysis of lateral radiographic cephalometry. Journal of Indian Academy of Oral Medicine and Radiology. 2011 Jul 1;23(3):179.

11. Missier MS, Samuel SG, George AM. Facial indices in lateral cephalogram for sex prediction in Chennai population–A semi-novel study. Journal of Forensic Dental Sciences. 2018 Sep;10(3):151.
12. Qaq R, Mânica S, Revie G. Sex estimation using lateral cephalograms: a statistical analysis. Forensic Science International: Reports. 2019 Nov 1;1:100034.