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Research Paper: The Credibility of Cephalogram Parameters in Gender Identification From Medico-Legal Relevance Among the Iranian Population

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ABSTRACT

Background: Normal cephalogram parameters seem to be gender discriminative and thus applicable in forensic medicine. We assessed validity of cephalogram parameters in gender identification among the Iranian population.

Methods: This cross-sectional study was conducted on 75 Iranian men and 75 Iranian women aged 25 to 54 years. On their first admission, the physicians requested for simple lateral skull X-ray for all participants.

Results: Using area under the ROC curve, gonion-gonion index (AUC=0.741) and vertex-mention index (AUC=0.697) had a moderate value to discriminate male from female gender, while other parameters lacked enough power to differentiate gender. The best cut-off point in gonion-gonion index for discriminating male from female gender was 103.75 with a sensitivity of 74.7% and a specificity of 65.3%. Also, the best cut-off value for vertex-mention index to differentiate two genders was 244.75 with a sensitivity of 74.7% and a specificity of 62.7%. By considering two parameters of gonion-gonion and vertex-mention, it is possible to differentiate males from females with a sensitivity of 82.6% and a specificity of 71.8%.

Conclusion: The two gonion-gonion and vertex-mention indices on cephalogram are applicable for gender discrimination.

1. Introduction

Personal identification through examining the skull bones characteristics plays an important role in identifying gender in unknown cadavers. In a world where crime, murder, disasters, and accidents have replaced instead of safety and comfort, research and diagnostic measures and procedures must not only be accurate but also be acceptable to identify the culprits. The assessment of anthropometric parameters is very important in forensic medicine and anthropologic studies. Anatomical and radiological investigations in estimating skeletal growth status and development of

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bones are the main methods of identifying gender. In the rotting cadavers where the soft tissues were completely destroyed, only skeletal remains can be used for personal identification [1].

Skull is a hard bony structure and well preserved after the death. This structure can be morphologically used for gender identity, especially after the decomposing of other body tissues and organs [2]. Lateral skull radiography is a proper clinical examination of the skull revealing numerous anatomical details and also can be more useful than profile appearance to identify gender and age. Gender identification based on skeletal features plays an important role in forensic legal medicine and anthropology [3]. After pelvic parameters, skull is the most important part for assessing gender [4].

In this regard, lateral and anteroposterior holography has a dominant role to reveal several details and landmarks. It has been shown that radiological indices of skull can be used to determine gender with high diagnostic accuracy [5]. In fact, normal cephalogram parameters seem to be very valuable in identifying gender and thus can be very applicable in forensic medicine [6]. Some studies even report high diagnostic value for skull parameters to predict gender [7-9]. The present study aimed to assess the validity of different cephalogram parameters in gender identification among the Iranian population.

2. Materials and Methods

This cross-sectional study was conducted on 75 Iranian men and 75 Iranian women aged 25 to 54 years referring to Rasoul Akram Hospital because of different medical reasons. On the first admission, the physicians requested simple lateral skull X-ray from all participants. The exclusion criteria included the history of skull trauma or surgery, chronic disorders, or any endocranial or facial defects as well as incomplete authentication documents or high-qualified radiograms. After preparing lateral skull radiograms, the parameters of these images were analyzed using PACS software.

In this study, 15 skull imaging parameters were assessed, including Gonion-Gonion (GOGO) or bigonial, Zygon-Zygon (ZYZY) or bizygomatic breadth, Euryon-Euryon (EUEU) or maximum cranial breadth, Vertex-Mention (VM) or maximum cranial height, Maxillary-Maxillary (MXMX) or maxillary width, inter-molar width of maxillary first molars (UMUM), inter-molar width of mandibular first molars (LMLM), Nasion-Mention (NM) or maximum face height, maximum height of frontal sinuous, maximum height of orbit, maximum breadth of orbit, orbital-orbital (biorbital breadth), upper facial height (nasion to subnasal), lower facial height (the distance between “Subnasal (SN) and Gonion (GN)” , and nasal breadth or ALAL.

Based on the measured parameters, the following indices were calculated: 1. Upper anterior index (UFI) (upper anterior facial height×100/bizygomatic breadth); 2. Total anterior Facial Index (TFI) (total anterior facial height×100/bizygomatic breadth); 3. Face size (upper facial height×bizygomatic breadth); and 4. Orbital index (height of orbit divided by breadth×100). The measured parameters of skull, as well as gender and age variables, were all recorded in the study checklist.

The results were presented as Mean±SD for quantitative variables and as absolute frequencies and percentages for categorical variables. The normal distribution of study variables was checked by the Kolmogorov-Smirnoff test. The categorical variables were compared using the Chi-square test or Fisher’s Exact test. The quantitative variables were also compared using t test or Mann-Whitney U test. The ROC curve analysis was applied to evaluate the different measured skull parameters for gender discrimination. In this regard, the validity of the skull parameters to discriminate males from females was estimated by calculating the area under the ROC curve and then the best cutoff value for these parameters was determined to yield the optimized sensitivity and specificity. For the statistical analysis, SPSS V. 22.0 was used. P values of 0.05 or less were considered statistically significant.

3. Results

In total, 150 cases were included into the study. The Mean±SD age of the participants was 43.89±11.61 years ranged 20 to 60 years and half of them were male (75 men and 75 women). There was no difference between men and women regarding age (44.81±10.61 years for men versus 42.96±12.53 years for women, P=0.330). The Mean±SD UFI index was 47.19±4.17 (range: 32.19-61.09) and the Mean±SD TFI index was 104.25±7.87 (range: 86.01-130.35). Also, the Mean±SD orbit index was 108.58±13.73 (range: 67.96-153.68) and the Mean±SD face size was 7884.14±964.92 (range: 5613.30-9819.65).

Comparing skull parameters between men and women showed significant higher EUEU (P<0.001), OROR (P=0.030), ZYZY (P=0.003), MXMX (P=0.001), GOGO (P<0.001), VM (P<0.001), NM (P=0.003), SN (P=0.007),

Table 1. Area under the ROC curve to discriminate male from the female gender

Variable(s)	Area	Std. Error	Asymptotic Sig.	Asymptotic 95% CI	
				Lower Bound	Upper Bound
EUEU	0.688	0.043	0.000	0.604	0.771
OROR	0.613	0.046	0.017	0.523	0.703
ZYZY	0.644	0.046	0.002	0.554	0.734
ALAL	0.590	0.047	0.056	0.499	0.682
MXMX	0.653	0.045	0.001	0.564	0.741
GOGO	0.741	0.042	0.000	0.659	0.822
VM	0.697	0.043	0.000	0.613	0.781
NM	0.628	0.046	0.007	0.539	0.717
SN	0.631	0.045	0.006	0.542	0.719
Face size	0.657	0.045	0.001	0.569	0.745

EUEU: Euryon-Euryon; OROR: Orbital-Orbital; ZYZY: Zygon-Zygon; ALAL: Nazal Breadth; MXMX: Maxillary-Maxillary; GOGO: Gonion-Gonion; VM: Vertex-Mention; NM: Nation-Mention; SN: Sella-Nasion. Face size: Upper facial height×bizygomatic breadth

as well as face size (P=0.001) in men compared with women. Regarding association between the cephalogram parameters and age, we found no correlation between age and parameters of UFI (r=-0.034, P=0.679), TFI (r=-0.134, P=0.102), orbit index (r=-0.005, P=0.954), and face size (r=-0.097, P=0.236). Among all skull parameters, there was a negative correlation between age and the parameters of VM (r=-0.199, P=0.015) and NM (r=-0.161, P=0.049).

Of all skull parameters and using area under the ROC analysis (Table 1), gonion-gonion index (AUC=0.741, 95%CI: 0.659-0.822, P<0.001) and vertex-mention index (AUC=0.697, 95%CI: 0.613-0.781, P<0.001) had a moderate power to discriminate male from female gender, while other parameters lacked enough power to differentiate gender. The best cut-off point for gonion-gonion index to discriminate male from female gender was 103.75 yielding a sensitivity of 74.7% and a specificity of 65.3%. Also, the best cut-off value for vertex-mention index for discriminating genders was 244.75 yielding a sensitivity of 74.7% and a specificity of 62.7%. Overall, considering two parameters of gonion-gonion and vertex-mention, it is possible to differentiate males from females with a sensitivity of 82.6% and a specificity of 71.8%.

4. Discussion

Among various skull parameters in the Iranian adults, only two parameters of gonion-gonion and vertex-mention were valuable for gender identification. In this regard, by simultaneous considering of these parameters, gender identification can be achieved with partially high sensitivity and specificity. Using the discriminative power analysis, we could also reveal the best cut-off points of each parameter yielding the maximized predictive value for gender identification. However, because of insignificant differences in other indices between men and women, those indices were unable to distinguish genders.

Various studies in other regions could characterize cephalometric normal parameters of adults that help discriminate gender; however, the between-gender analysis led to considerable paradoxical differences. In Wu et al. (2007) study, there were statistically significant gender differences among 6 of 11 cephalometric variables in the Chinese people, but only 1 variable in the Caucasians [10]. There were also statistically significant ethnic differences for 8 variables in males and 7 variables in females indicating that the gender and ethnicity in cephalometric parameters are very different.

Interestingly, in a study by Fang et al. (2011) on the American population except for facial feature of each ethnic group (except North American black female and Korean female populations), for both male and female populations within each ethnic group, the level of variability for each facial measurement was matched closely in both genders [11]. The pointed observation was expected in their study because the unit-dependent differences in facial measurements due to the sexual dimorphism were eliminated by their method.

Amongst the ethnic groups surveyed, the mid-face widths ZYZY and Exocanthion-Exocanthion (EXEX) along with the lower face width, GOGO, showed the lowest level of variation. In a study on Turkish adults, most Turkish cephalometric measurements showed statistically significant sex differences. The comparison of Turkish men and women indicated larger values for men in all investigated linear measurements [12]. The study done by Ayoub et al. (2008) on Lebanese adults showed that men had significantly larger skeletal linear measurements: The mandibular base menton to gonion, the total mandibular length of condylon to gnathion and significantly larger angular measurements, including sella to nasion to subspinal point and sella to nasion to supramental point [5].

Finally, their study proved that male skeletal linear and angular measurements are significantly larger in Lebanese adult males than in females. Finally, in a study by Orish et al. (2014) on Romanian adults, the anthropometry of gnathion-gonion, gonion-gonion, and pogonion-gnathion was characterized and compared between the two genders [13]. In this regard, there was evidence of sexual dimorphism; male parameters were significantly higher than female so that the male and female ratios for the mean measurements were greater than one, indicating that the male crania were larger in all linear dimensions than female crania.

The calculated sexual dimorphism ratio of gnathion-gonion was 1.16, while it was 1.09 for pogonion-gnathion and gonion-gonion each. Finally, reviewing the literature indicates a powerful dependency of between-gender differences in cephalo-facial parameters on ethnical differences. In fact, according to our results on Iranian adults, only two indices of gonion-gonion and vertex-mention were significantly different between males and females, while in some ethnicities, almost all studied parameters were significantly different between the two genders emphasizing determination of special cephalo-facial parameters for gender determination. A given cephalometric analyses consist of a series of measurements designed to measure the different geometric parameters of the distinct facial items. Four basic parameters can be measured, including size, shape, position, and orientation.

5. Conclusion

According to our analysis, it seems that the parameters related to the shape of facial components have the highest value to discriminate male from female genders; however, this finding might not be applicable in other ethnicities.

Ethical Considerations

Compliance with ethical guidelines

The research protocol approved by the Ethics Committee of the Iran University of Medical Sciences,Tehran, Iran. Verbal consent was obtained from all of study subjects.

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Authors contributions

Participated in data gathering and date preparation: Azadeh Memarian, Seyed Reza Saadat Mostafavi, Elham Zarei, Shayesteh Ashrafi Esfahani; Designed and conducted the research, performed the statistical analyses, participated in all of the research, and prepared and edited the manuscript: Azadeh Memarian; Designed and conducted the research and corrected the English manuscript: Seyed Reza Saadat Mostafavi, Azadeh Memarian; and Read and approve the content of the manuscript: Azadeh Memarian, Seyed Reza Saadat Mostafavi, Elham Zarei, Shayesteh Ashrafi Esfahani,, Behjat Ghorbanzadeh.

Conflict of interest

The authors declared no conflict of interest.

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