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The Value of Lateral Cephalometric Variables Measured by Cephalogram in Sex Determining among Iranians

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Abstract

Purpose: Sex determination is one of the most important aspects of the personal identification in forensic medicine. The present study thus aimed to assess the value of cephalogram in determining sex by applying eleven linear and an angular cephalometric variables measured on lateral cephalograms among Iranians.

Methods: In a cross-sectional study, 11 linear and 1 angular cephalometric measurements were studied. Those are: basion to anterior nasal spine, upper facial height, length of cranial base, total face height, frontal sinus height, mastoidale to sella-nasion plan, mastoidale to porion-orbital plan, mastoid height from cranial base, mastoid with at the level of cranial base, mandibular effective length (central condyle to prognation), occipitofrontal diameter, and gonial angle. Measurements were assessed in 150 individuals (75 males and 75 females) aged 25 to 54 years. After preparing lateral cephalograms, the cephalometric measurements were analyzed using PACS software. SPSS version 22.0 was used for analysis. P values of 0.05 or less were considered statistically significant.

Results: With the exception of gonial angle, comparison of lateral cephalometric indices between two sexs showed greater values in males than in females ($p<0.001$). In general, almost all of the cephalometric measurements were found reliable to distinguish between male and female sex skulls with a high sensitivity (100%) and specificity (97.3% to 1000%).

Conclusion: The cephalometric measurements used in this study are able to differentiate with high specificity and sensitivity between male and female skull

Keywords: sex determination, cephalogram, lateral cephalometric variables

1. Introduction

Sex determination is one of the most important aspects of the personal identification in forensic medicine. The change in the shape of person occurs naturally after sexual maturity and changing the bones of the skull and pelvis are the most indicative for difference between the sexes (Bass, 1971; Sassouni, 1963; Scheuer, 2002; Veyre - Goulet, Mercier, Robin, & Guerin, 2008). The forensic anthropologists have mostly assessed the dimorphism in teeth, hair, pelvis, skull and in bone sizes. However, reliability of the skull parameters to identify sex until adulthood has remained uncertain (Biggerstaff, 1977; Iscan & Steyn, 2013; V. G. Naikmasur, R. Shrivastava, & S. Mutalik, 2010; K. R. Patil & R. N. Mody, 2005). Furthermore, appearance characteristics are not only dependent to sex, but they are influenced by different factors that person exposes to them throughout life. In the studies on the efficiency of skull parameters to identify sex, the accuracy of these parameters has estimated to be 77% to 92% (Paiva & Segre, 2003; Steyn & Işcan, 1998), while using parameters of skull radiography improved the accuracy to the range of 80% to 100% (Robinson & Bidmos, 2009). Classically, the skull morphology measured by cephalometric technique which is a radiographic method to define the geometry and size of the skull bones. Normally the lateral view of the cephalogram is considered in evolutionary studies because of the availability and reliability of its characteristics and it is used as reference (Bruner, 2004). Lateral cephalogram indicates the structural and morphological details of skull in a single radiography representing various points for comparing sexes. In addition, cephalometric tools and techniques are readily available, low-cost, repeatable, and without the need for special training to personnel (Chang, Liu, & Hsiao, 1996). Lateral cephalogram is a simple and reliable tool in forensic medicine and its results are reliable and can be generalized. However, a few studies have been performed to assess parameters on the skull in Iranian population. The present study thus aimed to assess the value of cephalogram in determining sex by applying 11 linear and 1 angular cephalometric measurements derived from lateral cephalograms among Iranians.

2. Materials and Methods

In this cross-sectional study, 150 individuals (75 male and 75 female) aged 25 to 54 years who referred to the Rasoul-e-Akram hospital in 2015 for various medical reasons were included. The study was performed according to Helsinki principals of ethics. A written consent was obtained from all participants and all of them were aware of the study. Using simple random sampling method was used to determine the sample size by considering the following formula and the previous studies data:

$$n = [\frac{Z_{\alpha} + Z_{\beta}}{C}]^2$$

C= 0.973, α= 0.05, β= o.1, $Z_{1-\alpha/2} = 1.96$, $Z_{1-\beta} = 1.28$, n=90

The subjects were eligible to include into the study after authentication using the national ID card, birth certificate or medical insurance. The exclusion criteria were history of skull trauma or surgery, history of chronic disorders, or any endocranial or facial defects. Also, those with incomplete authentication documents or high-qualified radiograms were not included. On first admission, the physicians requested simple lateral cephalometric radiograph for all participants. Eleven linear and one angular cephalometric measurements were analyzed using PACS software. Those measurements are: basion to 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 plan (Ma-SN), mastoidale to porion-orbital plan (Ma-FH), mastoid height from cranial base (Ma-Ht), mastoid with at the level of cranial base (Ma-wd), mandibular effective length (central condyle to prognotion), occipitofrontal diameter (occiput to frontal), and gonial angle (Ar-Go-Me). The measured skull parameters along with sex and age subgroups were all recorded in the study checklist.

For statistical analysis, results were presented as mean ± standard deviation (SD) for quantitative variables and were summarized by absolute frequencies and percentages for categorical variables. Test of normality were performed using the Kolmogorov-Smirnoff test. Categorical variables were compared using chi-square test or Fisher's exact test when more than 20% of cells with expected count of less than 5 were observed. Quantitative variables were also compared with t test or Mann-Whitney U test. The ROC curve analysis was applied to evaluate the different measured skull parameters for sex identification. In this regard, the value of the skull parameters to discriminate male from female sexes was examined by calculating area under the ROC curve and then the best cutoff value for these parameters were determined yielding the optimized sensitivity and specificity. For the statistical analysis, the statistical software SPSS version 22.0 for windows (SPSS Inc., Chicago, IL) was used. P values of 0.05 or less were considered statistically significant.

3. Results

In total, 75 males (mean age 36.4 ± 7.5 years) and 75 females (35.5 ± 5.8 years) were included. No difference was found in mean age between males and females (P = 0.400). As shown in Table 1, no difference was revealed in the mean cephalometric parameters between the difference age subgroups. Comparing lateral cephalometric indices between the two sexes (Table 2) showed that except for mean gonial angle that was significantly more in females compared with men (P < 0.001), other measured parameters were all more in males than in females (P < 0.001).

As shown in Table 3, a definitive cutoff values were obtained for some parameters including Ba_Ans (cutoff point of 10.6), N_Ans (cutoff point of 5.5), Ma_Sn (cutoff point of 4.0), Ma_FH (cutoff point of 2.0), Ma_Ht (cutoff point of 1.5), Ma_Wd (cutoff point of 2.5), Mand_leng (cutoff point of 8.0), and Occip_front (cutoff point of 21.7) for differentiating male from female sexes with a sensitivity of 100% and specificity of 100%. The best cutoff values for other parameters including Ba_N, N_M, Fs_Ht, and Ar_Go_Me were 11.2, 13.0, 3.4, and 123.8 respectively yielding a sensitivity of 100% for all and a specificity of 98.7%, 98.7%, 97.3%, and 98.7% respectively.

Table 1. Comparing lateral skull parameters between the different age subgroups

Age Groups	25-30	31-35	36-40	41-45	46-50	51-55	Total	P Value
Ba_Ans	10.6 ± 0.6	10.4 ± 0.5	10.7 ± 0.6	10.5 ± 0.4	10.6 ± 0.6	11.0 ± 0.4	10.6 ± 0.5	0.3
N_Ans	5.4 ± 0.5	5.4 ± 0.4	5.4 ± 0.4	5.4 ± 0.4	5.4 ± 0.3	5.8 ± 0.08	5.4 ± 0.4	0.4
Ba_N	11.0±0.7	10.8 ± 0.7	11.0 ± 0.7	10.9 ± 0.7	11.0 ± 0.6	11.7 ± 0.2	11.0 ± 0.7	0.2
N_M	12.9 ± 0.7	12.6 ± 0.7	13.1 ± 1.4	12.9 ± 0.6	12.8 ± 0.8	13.7 ± 0.2	12.9 ± 1	0.2
Fs_Ht	3.4 ± 0.3	3.3 ± 0.3	3.5 ± 0.4	3.4 ± 0.3	3.5 ± 0.3	3.7 ± 0.1	3.4 ± 0.3	0.3
Ma_Sn	4.1 ± 0.7	3.9 ± 0.7	4.0 ± 0.8	4.0 ± 0.8	4.0 ± 0.8	4.7 ± 0.1	4.0 ± 0.7	0.3
Ma_FH	2.0 ± 0.6	1.8 ± 0.6	2.0 ± 0.7	1.9 ± 0.7	2.0 ± 0.6	2.6 ± 0.2	2.0 ± 0.7	0.3
Ma_Ht	1.5 ± 0.3	1.4 ± 0.3	1.5 ± 0.4	1.4 ± 0.3	1.4 ± 0.3	1.8 ± 0.1	1.5 ± 0.3	0.3
Ma_Wd	2.4 ± 0.3	2.3 ± 0.3	2.4 ± 0.4	2.3 ± 0.4	2.4 ± 0.4	2.8 ± 0.2	2.4 ± 0.3	0.2
Ar_Go_Me	125.3±13.4	123.9±2.7	123.4±2.8	123.5±2.8	123.3 ± 3	120.6 ± 1	124.0 ± 7.6	0.7
Mand_leng	7.9 ± 0.6	7.8 ± 0.7	7.9 ± 0.7	7.9 ± 0.6	7.9 ± 0.7	8.5 ± 0.3	7.9 ± 0.6	0.4
Occip_front	21.5 ± 0.3	21.3 ± 0.3	21.4 ± 0.4	21.4 ± 0.4	21.4 ± 0.3	21.7±0.06	21.4 ± 0.3	0.4

Table 2. Comparing lateral skull parameters between men and women

Parameter	Men	Women	P-value
Ba-ANS	11.1 ± 0.42	10.1 ± 0.11	< 0.001
N-ANS	5.8 ± 0.10	5.1 ± 0.33	< 0.001
Ba-N	11.7 ± 0.18	10.3 ± 0.3	< 0.001
N-M	13.6 ± 0.2	12.3 ± 1.05	< 0.001
FS-Ht	3.8 ± 0.1	3.1 ± 0.1	< 0.001
Ma-SN	4.8 ± 0.1	3.3 ± 0.2	< 0.001
Ma-FH	2.6 ± 0.2	1.3 ± 0.3	< 0.001
Ma-Ht	1.8 ± 0.1	1.1 ± 0.1	< 0.001
Ma-wd	2.6 ± 0.2	1.3 ± 0.3	< 0.001
Ar-Go-Me	121.8 ± 10.4	126.1 ± 0.61	< 0.001
Mand_leng	8.5 ± 0.28	7.2 ± 0.10	< 0.001
Occipitofrontal	21.8 ± 0.09	21.1 ± 0.1	< 0.001

Table 3. The especial cutoff points for lateral skull parameters in men and women

Parameter	Cutoff Point for Men	Cutoff Point for Women
Ba-ANS	> 10.6	< 10.6
N-ANS	> 5.5	< 5.5
Ba-N	> 11.2	< 11.2
N-M	> 13.0	< 13.0
FS-Ht	> 3.4	> 3.4
Ma-SN	> 4.0	< 4.0
Ma-FH	> 2.0	< 2.0
Ma-Ht	> 1.5	< 1.5
Ma-wd	> 2.5	< 2.5
Ar-Go-Me	< 123.8	> 123.8
Mand_leng	> 8.0	< 8.0
Occipitofrontal	> 21.7	< 21.7

4. Discussion

Physical anthropology was primarily introduced because of interesting to ethnical categorization as well as quantitative measurement of body dimensions. Thus, the factors dependent to geographical, ethnical, and anthropological indices determine diameters of human body. In this regard, anthropometric studies should be focused on especial demographic, geographical and ethnical subgroups. Because of the importance of determining these diameters in forensic medicine in each society, we aimed to determine some especial facial and cephalic diameters among Iranian population to discriminate male from female sex. The different methods for assessment of skull bones include morphological assessment that depend to experiences of the assessor and thus may be accompanied with a potential error. Therefore, the application of more accurate methods based on morphometric measurements is strongly recommended (Kanchan & Rajendra, 2005). In this regard, the use of morphologic measures for discrimination of sexes is one of the most common method (Kumar, Lone, & Patnaik, 2013). Even, the combination of two or more indicators can increase accuracy of this sex discrimination (Ingerslev & Solow, 1975). In fact, considering skull parameters along with pelvic or bones of extremities can achieve sex identification with the highest accuracy (Jacobson, 1995).

As shown in our study, the measurement of lateral skull diameters could perfectly differentiate male from female sex with high sensitivity and specificity. In fact, considering especial cutoff points for some diameters such as Ba_Ans, N_Ans, Ma_Sn, Ma_FH), Ma_Ht, Ma_Wd, Mand_leng, and Occip_front can differentiate sexs with high accuracy. In other words, using any of the indicators alone can be applicable for this purpose. Previous studies mostly obtained similar results on sex determination from skull parameters. In a study by Naikmasur et al (Venkatesh G Naikmasur, Rahul Shrivastava, & Sunil Mutalik, 2010), a total of 11 cephalometric parameters were traced on lateral cephalograms that among those, bizygomatic width, ramus height, depth of face contributed most for sexual dimorphism in the population with the discrimination accuracy ranged 81% to 88%. In a study by Mathur et al, 4 linear measurements including N-S, Me- Go, N – ANS and Co- Gn and 2 angular measurements including gonial angle and Mand pl angle were significantly different between the sexs, indicating the presence of sexual dimorphism in the skull (Mathur, Mahajan, Dandekar, Patil, & Mathur, 2014). In a study by Butt et al. the reliability of cephalogram in determining skull gender dimorphism was evaluated and it was found that the percentage of skulls correctly classified with this function was 94.2% (Butt & Ahmedb, 2016). In a study by Veyre et al (Veyre - Goulet et al., 2008), sex was determined with 95.6% accuracy using the 18 variables discriminant function that a subset of eight variables was selected and could predict sex with the same accuracy. In another study by Binnal et al (Binnal & Devi, 2012), among 9 cephalometric parameters used, seven were reliable in the identification of sex. That the derived discriminant function equation accurately identified 88% of the male study subjects as males and 84% of the female subjects as females. Patil et al also (Kanchan & Rajendra, 2005) showed that a discriminant function derived from 10 cephalometric variables provided 99% reliability in sex determination. In Hsiao et al (Chang et al., 1996) survey, the superciliary ridges, frontal sinuses, external occipital protuberance, and mastoid processes were adopted as objects of lateral radiographic cephalometric measurements. With discriminant functions created from 18 established cephalometric variables, a total of 100 cases were classified into two sexual groups with 100% accuracy in a random sample of Taiwanese adults. Study by Sprowl et al which was evaluated 24 factors, the landmarks contributing the most ($P < 0.05$) to sexual dimorphism were GMFH, IOpFH, ULTc, GPI, GSgN, FSHt and Tc. The results of this study confirm sexual dimorphism does exist in the skeleton as early as 6 years old (Sprowl, 2013).

In total, the obtained results can explain some important points. First, comparing different studies on various populations achieve similar results on sensitivity and accuracy of lateral cephalometric parameters in sex identification. In fact, almost all studies emphasized this fact that by employing any of these parameters, sex can be identified perfectly. The difference in the variables in studies are related to the ethnic population (Kanchan & Rajendra, 2005). Second, it seems that considering a combination of these parameters and definition of a combined scaling system consisting these parameters, sex discrimination in unidentified cadavers or mutilated corpses can be easily and quickly performed only on measurement of lateral skull diameters. In total, lateral cephalogram not only is ideal for the skull examination as it gives details of various anatomical points in a single radiograph, but also it easily provides architectural and morphological details of skull superstructures and intra-cranial details for sex comparisons.

Competing Interests Statement

The authors declare that there is no conflict of interests regarding the publication of this paper.

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