# The value of lateral cephalometric image in sex identification

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## ABSTRACT

Background: Determination of sex and estimation of stature from the skeleton is vital to medicolegal investigations. Skull is composed of hard tissue and is the best preserved part of skeleton after death, hence, in many cases it is the only available part for forensic examination. Lateral cephalogram is ideal for the skull examination as it gives details of various anatomical points in a single radiograph. This study was undertaken to evaluate the accuracy of digital cephalometric system as quick, easy and reproducible supplement tool in sex determination in Iraqi samples in different age range using certain linear and angular craniofacial measurements in predicting sex.

Materials and Method The sample consisted of 113of true lateral cephalometric radiographs for adults with age range from 22-43 years old (51 males, 62 females), using certain linear and angular craniofacial measurements with the aid of computer program "AutoCAD 2007"

Results: The eleven parameters measured for males and females when compared are statistically significantly different. All cranio-cephalometric measurements gave overall predictive accuracy of sex determination by discriminant analysis (86.7%). The stepwise selection method gave overall predictive accuracy of sex determination by discriminant analysis (85.8%). Age showed no statistical difference among the studied age range except for the distance from Mastoid to Frankfort plane.

Conclusion: The lateral cephalometric measurements of craniofacial bones are useful to support sex determination of Iraqi population in forensic radiographic medicine.

Keyword: Sex determination, lateral cephalgram, discriminant analysis, craniofacial measurements. (J Bagh Coll Dentistry 2013; 25(2):54-58).

## INTRODUCTION

Sex determination of skeletal remains is part of archaeological and many medico-legal examinations. The methods vary and depend on the available bones and their condition. The only method that can give a totally accurate result is the DNA technique, but in many cases for several reasons it cannot be used. Anthropological measurements of the skeleton and the comparison with existing standard data must then be applied and may help to differentiate between male and female remains. On an individual basis however, sex differences are not always distinctive, but taken collectively they can give a good indication in the majority of cases [1].

Identification of skeletal and decomposed human remains is one of the most difficult skills in the forensic medicine. Sex estimation is an important problem in the identification.

If all the bones composing the skeleton are present, sex estimation is not difficult , as can be determined with 100% accuracy.

This estimation rate is 98% in existence of pelvis and cranium, 95% with only pelvis or pelvis with long bones and 80-90% with only long bones. However, in explosion, warfare and other mass disasters like aircraft crashes, identification and sex determination are not very easy [2,3].

Ceballos and Rentschler in 1958[4] compared the posterio-anterior radiographs of 100 males and 100 females adult skulls and claimed 88% success in sexing the skulls.

Kaptanoglu and Ozedmir study in 2001[5] about sex determination found that the accuracy rate of the thickness of the skull was found to be 74.7% in male and 67.6% in female.

The present study is an attempt to derive a discriminant function to determine sex and to evaluate the accuracy of digital cephalometric system as quick, easy and reproducible supplement tool in sex identification in Iraqi samples in different age range and to establish the effectiveness of certain linear and angular craniofacial measurements in predicting sex.

## MATERIALS AND METHOD

For this study, total 113 normal healthy adults originating from Iraqi origin, comprising of 51 males and 62 females, their ages ranging between 22-43 years old were selected at the Oral Diagnosis and Orthodontic Departments, College of Dentistry/ University of Baghdad, in addition to cephalometric images saved in archives (pro- and retrospective study).

To ensure the selection of normal healthy person, detailed history of each patient was taken, no history of abnormal habits, no apparent facial disharmony or cleft lip and palate, no history of orthodontic, orthopedic or facial surgical treatment, symmetrical faces with normal

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occlusion skeletal class I, ANB angle between 2-4 degrees [6]. Images of good quality had the clearest reproduction of lateral anatomical cephalometric landmarks depiction a reference ruler on the cephalostat for exact measurement of the magnification factors.

New participants were carefully informed about the aim and the method of investigation of the study and they were free to accept or refuse.

All the radiographs were taken in the oral diagnosis, College of Dentistry, Baghdad University, using DIMAX3 Digital X-ray unit system machine (Finland) , The correct exposure parameters for the individual being X-rayed were selected according to the User's manual (2004)[7] as shown in Table (1).

**Table 1: Lateral View Exposure Values (User's manual, 2004).**

| Patient | kV Value | mA Value |
|---|---|---|
| Adult female or small male | 68 | 5 |
| Adult male | 70 | 5 |
| Large adult male | 72 | 5 |

All lateral cephalometric image were analyzed by Auto CAD program (version 2007) to identify cephalometric points and plane landmarks when image was imported to AutoCAD program , it was appeared in the master sheet on which the points were determined, and measurements were obtained, after correction of magnification.

The magnification was corrected by multiplying the readings by the magnification factor which was obtained as a ratio between the real distance measurements for a scale and the distance measurements for the same scale from radiographic image; after that the measurements were saved on an Excel sheet with their records in degrees for angular measurement and in millimeter for linear measurements.

**The cephalometric bony landmarks, which were used in this study, include the following:**

Glabella (G) most anterior point in the midsagittal plane between the superciliary arches, Basion (Ba)lowest point on the anterior rim of the foremen magnum in the median plane , Anterior Nasal Spine (ANS) it's the tip of the bony anterior nasal spine in the median plane , Nasion (N) The most anterior point on the naso-frontal suture in the median plane, Menton (M) The lowest point on the symphyseal shadow of the mandible seen on a lateral cephalogram, Opisthocranion (Op)most prominent point of the occipital bone in the midline , Mastoidale (Ma)lowest point of the mastoid process, Sella (S) The midpoint of the hypophysial fossa , V1 and V2 upper and lower parameter of the frontal sinus cavity respectively

**Cephalometric Planes Used in Measurements**

SN plane (Sella-Nasion): it is the anterior posterior extent of anterior cranial base , Frankfort horizontal plane (FH): It is a horizontal plane running between porion and orbitale.

**Lines Used in the Measurements**

G–Op: maximum length of skull ,the distance was obtained from glabella (G)to Opsithocranium (Op), FsHt: (V1–V2) frontal sinus height, the distance from upper and lower parameter of frontal sinus cavity, Ba–N: length of cranial base, the distance was obtained from basion (Ba) to nasion(N), N–ANS: upper facial height, the distance was obtained from nasion(N) to anterior nasal spine(ANS), N–M: total face height, the distance was obtained from nasion (N) to menton(M), Ba–ANS: the distance was obtained from basion to anterior nasal spine , Ma–SN: perpendicular distance was obtained from mastoidale to SN plane, Ma–FH: perpendicular distance was obtained from mastoidale to FH plane.

**Angle Used in Measurements:**

Ba-N-M angle: the angle which between basion & nasion& menton, M-N-ANS angle: the angle which between menton & nasion & anterior nasal spine, S-N-M angle: the angle which between sella & nasion & menton.

Initially mean values, standard deviations and co-efficient of variation were calculated for all the variables, the values derived were compared between both the sexes using Student's t-test. Discriminant analysis was used to test the performance of all the 11 measurements and indices (used together in a univariate modelling) in differentiating male from female sex. The resulting discriminant score (D score) from using the equation could be used in predicting sex based on cranial measurements and indices. The stepwise selection method of discriminant analysis was used next to select from the tested 11 measurements only those that contribute to the bulk of discrimination power of the model. ROC analysis on the other hand is a univariate analysis testing the discrimination power of each measure when used alone. A multiple linear regression model was used to study the net and independent effect of sex after adjusting for age on each of the 11 quantitative outcome (dependent) variables.

The performance characteristics (validity) of a test or criteria, include among others: sensitivity, specificity, positive predictive value and negative predictive value.

# RESULTS

The mean values for males were significantly greater than those for females for all linear measurements and two angular measurements except for angle degree (M_N_ANS), the discriminant function was highly significant and therefore all the 11 variables were useful in determination of sex, as shown in table (2).

**Table 2: Mean, standard deviation, standard error, p (t-test), sexual dimorphism for 11 variables**

| Variables | Female | | | Male | | | P (t-test) | Sexual dimorphism (% difference compared to females) |
|---|---|---|---|---|---|---|---|---|
| | Mean | SD | SE | Mean | SD | SE | | |
| **(G_OP)mm** | 174.2 | 8.5 | 1.08 | 184.4 | 8.3 | 1.17 | <0.001 | 5.9 % |
| **(V1_V2mm** | 26.8 | 5.7 | 0.72 | 30.1 | 4.6 | 0.64 | 0.001 | 12.3 % |
| **(Ba_N) mm** | 98.1 | 5.1 | 0.64 | 105.1 | 6.4 | 0.9 | <0.001 | 7.1 % |
| **(N_ANSmm** | 50.5 | 3.3 | 0.41 | 54.2 | 4.1 | 0.57 | <0.001 | 7.3 % |
| **(N_M) mm** | 113.2 | 6.2 | 0.79 | 122.8 | 6.7 | 0.93 | <0.001 | 8.5 % |
| **(Ba_ANS)mm** | 93 | 5.5 | 0.7 | 99.4 | 6 | 0.84 | <0.001 | 6.9 % |
| **(Ma_SN) mm** | 36.2 | 4.8 | 0.61 | 40.6 | 5.3 | 0.74 | <0.001 | 12.2 % |
| **(Ma_FH) mm** | 25.6 | 4.1 | 0.52 | 27.3 | 4.1 | 0.58 | 0.03 | 6.6 % |
| **Angle degree (Ba_N_M)** | 58 | 2.6 | 0.32 | 59.2 | 3.1 | 0.43 | 0.028 | 2.1 % |
| **Angle degree (M_N_ANS)** | 11.2 | 2.4 | 0.3 | 9.9 | 2.5 | 0.34 | 0.005 | -11.6 % |
| **Angle degree (S_N_M)** | 76.3 | 3 | 0.38 | 78.2 | 3.9 | 0.55 | 0.004 | 2.5 % |

All the 11 cephalometric measurements and indices were used together in discriminant model to differentiate between males and females. The resulting equation was statistically significant and able to predict sex with overall accuracy of 86.7%.The total facial height distance ranked first in its predictive power followed by the length of cranial base distance, the maximum length of skull, linear distance (Ba_ANS), upper facial height distance, linear distance (Ma-SN), frontal sinus height distance, angle degree (S-N-M), the angle degree (M-N-ANS). The angle degree (Ba-N-M) and the linear distance (Ma-FH) are least contribution to the model. The resulting discriminant score (D score) from applying the specific value of each measurement and index in the equation could be used in predicting male sex if D score ≥0.104 (cutoff value) otherwise its labeled as female sex. The stepwise selection method was used next to select from the total 11 tested measurements, only those contributing to the major part of discrimination power of model. Only 3 of 11tested variables were enough to provide a statistically significant equation with an overall predictive accuracy of 85.8% which is almost near to the previously reported discriminant model containing all 11 measurements .These variables were in order of importance, starting from the most important:the total facial height ; followed by; the length of cranial base ; and finally; (S-N-M) angle as shown in table (3, 4).

**Table 3: Discriminant Model for 11 selected measurements when used to discriminate between Male and Female sex.**

| Variables | Rank according to importance (discriminating power) |
|---|---|
| **Linear distance (N_M) mm** | 1 |
| **Linear distance (Ba_N) mm** | 2 |
| **Linear distance (G_OP) mm** | 3 |
| **Linear distance (Ba_ANS) mm** | 4 |
| **Linear distance (N_ANS) mm** | 5 |
| **Linear distance (Ma_SN) mm** | 6 |
| **Linear distance (V1_V2) mm** | 7 |
| **Angle degree (S_N_M)** | 8 |
| **Angle degree (M_N_ANS)** | 9 |
| **Angle degree (Ba_N_M)** | 10 |
| **Linear distance (Ma_FH) mm** | 11 |

**Table 4: Discriminant Model for 11 elected measurements when used to discriminate between Male and Female sex. The Stepwise Selection Method was used.**

| Variables | Rank according to importance (discriminating power) |
|---|---|
| **Linear distance (N_M) mm** | 1 |
| **Linear distance (Ba_N) mm** | 2 |
| **Angle degree (S_N_M)** | 3 |

# DISCUSSION

In establishing the identity of sex from a defleshed skull, lateral cephalograms and PA radiographs assumes a pre-dominant role, as they can provide architectural and morphological details of the skull, thereby revealing additional characteristics and multiple points for comparison [8].

In sexing a skull the initial impression often is the deciding factor, a large and robust skull is generally a male; a small and gracile skull is of a female [9,2], this subjective approach of sexing skull by inexperienced individual may produce misleading results. However methods based on measurements and morphometry are accurate and therefore can be used in determination of sex from skull. Next to pelvis, skull is the most easily sexed portion of the skeleton, but the determination of the sex from the skull is not reliable until well after puberty [9,8]**.**

In the present study 11 cephalometric measurements were used in discriminant function analysis and they provided very good sex discrimination in Iraqi subjects of known sex.

Lazic et al [10] performed various measurements on 64 skulls by electron gilding meter goniometer to study basic craniometric and skeletotopic characteristics of facial skeleton and hard palate in osteologic samples and found that the average length of skulls was (173.27±7.355)mm ;all the male skulls had higher values than the females skulls and their ratio was 175.59:170.94 mm., these values were lower than that of the current study because of different methodology used and as a result of the racial anatomic variety in the studied samples.

Zavando et al[11] performed sex determination from lineal dimensions in a sample of human skulls collection belonging to the Universidade Federal de Sao Paulo (UNIFESP), the sample comprised 149 males skulls with a mean of age of 43.41 years old and 77 females skulls with a mean of age of 38.19 years old. This sample considered skulls from individuals with white, brown, and black skin, the means of all the analyzed lineal dimensions were larger in the men skulls than in the women skulls. Nevertheless G -Op, Na-Pr (Nasion – Prosthion), Zi-Zi (Bizagomatic), and Na-ANS were statistically significant with $p < 0.05$.

The result of this study showed the skull of human exhibits anatomic variability between sexes. All the 11 cephalometric measurements and indicies are used together in discriminant model to differentiate between males and females. The resulting equation was statistically significant and able to predict sex overall accuracy of 86.7%.

Altayeb et al [12] found that males had statistically significantly greater measurements than females. Complete crania showed a high degree of sexual discrimination with 83.6% success for recent Northern Sudanese for all variables and using stepwise discriminant function analysis only three variables were selected as the best discriminant between sexes was the glabello-occipital length being the most dimorphic followed by the basion-nasion length and basion-bregma height 81.8% accuracy was obtained.

Sumati et al [13] found that four variables of mastoid process sexed with 76.6% accuracy of the sample while stepwise discriminant function analysis, mastoid length was found to the best determinant that alone correctly sexed the sample with an accuracy of 66.7%.

While the current study the first ranked in discrinimt power was (N-M) with 87.3% diagnostic accuracy and this due to different method was used (magnification factor), different populations and geographical regions.

The success rates obtained in this study are generally similar to those obtained in various parts of the world e.g. South Africans, Cretan, White and Black Americans (82-89%), and Japanese who showed 84.1% for crania and mandible; but they are less than those obtained in Indians (90%), Taiwanese (100%) and Chinese (96.7%); and also sex prediction using the complete cranium was better than using fragmentary crania [13].

From the above study, following conclusions were made. All selected linear and angular craniofacial measurements shown significant statistical differences between males and females and give strong predictive accuracy of sex determination by discriminant analysis, the stepwise selection method which choose only three from eleven parameters in order of importance, starting from the most important: the total facial height ;followed by; the length of cranial base ;and finally; (S-N-M) angle and give overall predictive accuracy of sex determination nearly equal to all eleven craniofacial parameters by dicreminant analysis, male sex was associated with statistically significant positive association with all the linear measurements and 2 angular measurements compared to females after adjusting the possible age effect and the effect of male sex was negative (reduction) on (M-N-ANS) angle, (Ma-FH) linear measurement in which the positive effect of male sex was small and failed to reach statistical significance after adjusting for the obviously important positive effect of increasing age, the age effect in the all the remaining 10 indices evaluated was not statistically significance during the age interval of 22-43 included in the current study.

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