SEXING THE HUMAN SKULL THROUGH THE MASTOID PROCESS

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OBJECTIVE: The purpose of this study was to evaluate the significance for sex determination of the measurement of the area formed by the xerographic projection of 3 craniometric points related to the mastoid process: the porion, asterion, and mastoidale points.

METHOD: Sixty skulls, 30 male and 30 female, were analyzed. A xerographic copy of each side of the skull was obtained. On each xerographic copy, the craniometric points were marked to demarcate a triangle. The area (mm^2) of the demarcated triangle for each side of the skull (right (D) and left (E) sides) was determined, and the total value of these measures (T) was calculated.

RESULTS: Concerning the right area of the male and female skulls, 60% of the values overlapped; for the left area, 51.67% overlapped, and for the total area, 36.67% overlapped. The analysis of the differences between the sexes in the areas studied was significant for the 3 areas. Regarding the total area, which is the preferred measurement because of the asymmetry between the sides of the skull, the value of the mean was 1505.32 mm^2 for male skulls, which was greater than the maximum value obtained in the female skulls. The value of the mean for female skulls was 1221.24 mm^2, less than the minimum value obtained for the male skulls.

CONCLUSIONS: This study demonstrates a significant result in the 3 studied areas, (D), (E), and (T). The total area values show less overlapping of values between the sexes, and therefore can be used for sexing human skulls. For the population studied, values of the total area that were greater than or equal to 1447.40 mm^2 belonged to male crania (95% confidence). Values for this area that were less than or equal to 1260.36 mm^2 belonged to female crania (95% confidence).

DESCRIPTORS: **Forensic medicine. Forensic anthropology. Anthropometry. Mastoid. Sexual characteristics.**

INTRODUCTION

Historically, human identification is one of the most challenging subjects that man has confronted. The concept of identity, with few significant variations, is the same as the assertion of Alves[1] that identity is a set of physical characteristics, functional or psychic, normal or pathological, that define an individual.

Nowadays, human identification is a universal process based on scientific principles, mainly involving fingerprinting, the objective of which is to identify and register individuals for both civil and criminal identification purposes. According to Arbenz[2], the application of the knowledge of physical anthropology for the purpose of forensic medicine constitutes forensic anthropology.

The identification of human remains, when it is not possible to apply the scientific method of fingerprint identification, demands a forensic medicine investigation. This skillful process, carried out by a coroner using knowledge of other professional areas, characterizes the medico-legal identification and is based on the application of knowledge of forensic anthropology.

The protocols of application of this knowledge by the authors in this area are not very different. The determination of the sex of skeletons represents an important stage in the execution of the forensic anthropological examination. The studies for sex determination are based on the dimorphism between the sexes that is present in the majority of human bones.

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Reichs[3] stated that the application of some existing methods of study occurs through two main approaches: by comment and description of the morphology of the bones in question, and by the values obtained using morphometry, or in other words, the measurement of these bones. A summary of the main differences in bones that present dimorphism between the sexes is presented by Bass[4], Ubelaker[5], Stewart[6], Rathbum and Buikstra[7], and Krogman and Íscan[8].

These authors emphasize the dimorphism of the pelvis and the skull. Krogman and Íscan[8] state that determination of sex, age, and race in a collection of 750 skeletons was possible, with levels of reliability of 100% when all the skeleton was present, with 95% reliability when using the pelvis alone, 92% using the skull alone, and 98% using the pelvis and the skull. This clearly demonstrates the importance of these regions—the skeleton, pelvis, and skull—for sex determination in forensic anthropological examinations.

Bass[4] says that the skull is probably the second best region of the skeleton to determine the sex. Broca (1875), and Hoshi[9] have already suggested that when skulls were placed on flat surface, the male skulls rest on the mastoid processes, while the female skulls rest on the occipital condyles or other portions of the skull. A great many researchers have studied the dimorphism of the mastoid process between the sexes through the use of its measurements, in isolated form or through the product between its values, emphasizing in a general way that the mastoid process is larger in the male.

Many authors, cited by Wahl and Henke[10], have highlighted the importance of the petrous portion of the temporal bone and its general preservation in the case of burning. This preservation occurs for two reasons: the compact structure of the petrous portion and its protected position at the base of the skull. Thus, this anatomical region is favorable for sex determination due to its craniometric characteristics. Upon careful examination of the available literature, we can recognize the following:

1 - the importance of the skull for sex determination;
2 - the importance of the temporal bone for anthropological studies due to its robustness and its location, usually making it possible to examine it in fragmented or burned skulls;
3 - the interest demonstrated by authors, since the last century, in the study of the mastoid process for the sex determination, both through its morphological traits (descriptive manner) and its measurement (morphometry);
4 - the search for related mathematical values to the mastoid process obtained by craniometric techniques that better demonstrate dimorphism between the sexes;
5 - the superior results demonstrated in studies that make use of multiple measurements rather than an isolated measurement of the mastoid process to determine the sex of skeleton;
6 - the significant results demonstrated in studies that make use of the dimorphism between the sexes of the correlation between the surface of the mastoid process and the robustness of the mastoid process;
7 - the scarcity of Brazilian national studies utilizing material of our ethnic and biological make up.

Thus, the present study, which was carried out using resources generally available to the majority of medical examiner's offices, is founded on an easily applied methodology and is based on our anthropologic archives.

METHODS

This study involved the use of 60 skulls that were housed in the collection of the Forensic Anthropology Laboratory of the "Setor de Perícias Médico-Legais" of Guarulhos during the period of January to July of 1997. In this study, the skulls (30 males and 30 females) had been obtained through the exhumation of identified cadavers that had anthropological data, including the date of death, sex, age, and color, which is registered in the archives of the Municipal Cemetery Necropolis of Campo Santo, Guarulhos, São Paulo.

Adult skulls of mature individuals, 18 or more years old, that had no destruction of the mastoid region or absence of metopic bone in the region of the craniometric points were chosen for the study. A xerographic copy of each side of the skull was obtained through a standardized technique, as demonstrated in figure 1. The skull under study was kept on the copying surface supported by 2 points:

a) the lateral surface of the mastoid process;
b) the zygomatic arc.

The objective of the technique proposed was to obtain a xerographic copy with as little distortion as possible. This was achieved by resting the mastoid process on the surface of the copier.

After the copies were made, each xerographic copy was identified with the identification number of the skull.

The device used to obtain the xerographic copies was a XEROX model 5334.

On each xerographic copy, we marked these craniometric points:

1 - Porion – the uppermost lateral point of the external auditory meatus;
2 - Asterion – the meeting point of the lambdoid, occipitomastoid, and parietomastoid sutures;

3 - Mastoidale – the lowest point of the mastoid process.

We then drew a triangle linking these three points. The resulting triangle was our object of study (Figure 2).

Once demarcated the triangle was transferred to tracing paper and its area calculated.

The values used for the present study, in mm^2, were obtained through the calculation of the area of the demarcated triangle on each side of the skull, right and left, called right area (D) and left area (E), respectively, and the value of the total of these 2 measurements, the total area (T).

The decision to use the value of the total area in the study was based on the evidence obtained by Helmuth[11], Schmitt and Saternus[12] and Demoulin[13] of the asymmetry of the mastoid process between the sides of the skull.

Figure 1 - The standardized technique for obtaining a xerographic copy of the skull.

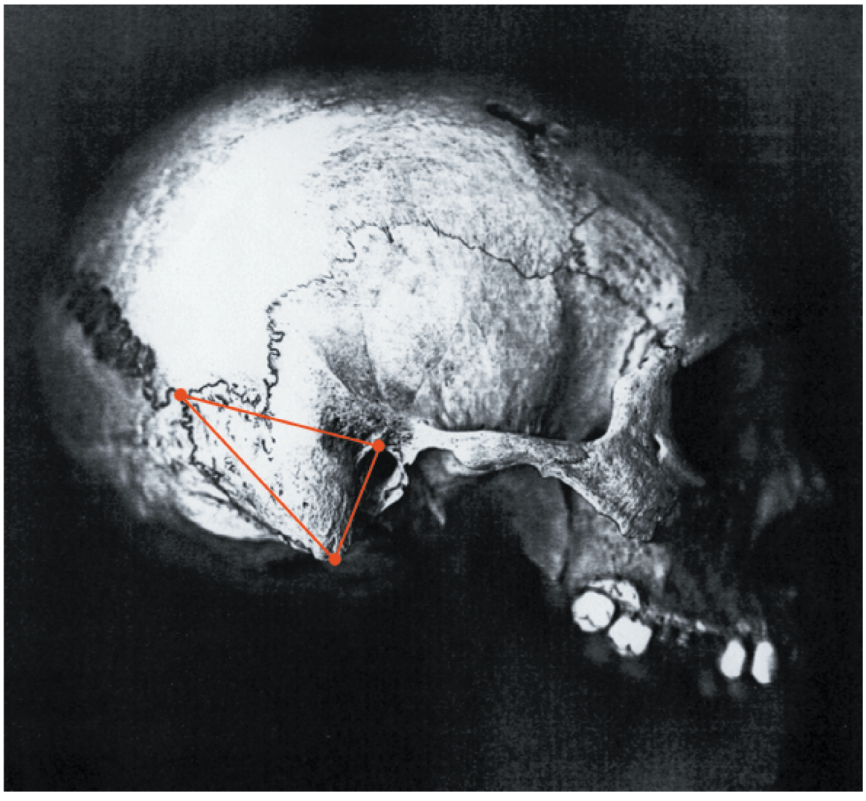

Figure 2 - The area of the demarcated triangle used for the study.

RESULTS

In the group of male skulls, we found the values in Table 1.

In the group of the female skulls, we found the values in Table 2.

The overlapping of the values of the right area (D) between the male and female skulls was 60%. The overlapping of the values of the left area (E) between the male and female skulls was 51.67%. The overlapping of the values of the total area (T) between the male and female skulls was 36.67%. The analysis of the difference between the male and female skulls, using Student's *t* test, is presented in Table 3. The values of the mean, the standard error mean and the 95% confidence interval for the mean are presented in Figure 3.

DISCUSSION

The objective of this study was to demonstrate that through a practical, easily applied methodology, it is feasible for the majority of the medical examiner's offices to determine the sex of skulls. This can be done using readily available resources. Based on a sample of our anthropological archives, we show that the triangle area measurement demarcated through the xerographic projection of cranio-

Table 1 - Reference values for the study in male skulls.

	RIGHT AREA (D) (mm^2)	LEFT AREA (E) (mm^2)	TOTAL AREA (T) (mm^2)
MINIMUM	539.00	612.50	1248.00
MAXIMUM	945.00	910.00	1855.00
MEAN	752.10	753.22	1505.32

Table 2 - Reference values for the study in female skulls.

	RIGHT AREA (D) (mm^2)	LEFT AREA (E) (mm^2)	TOTAL AREA (T) (mm^2)
MINIMUM	471.50	462.00	942.00
MAXIMUM	742.00	750.00	1475.00
MEAN	608.70	602.54	1211.24

Table 3 - Analysis of difference of the areas studied using the Student *t* test.

AREA	t	Gl	SIGNIFICANT at *P* <.05
RIGTH **(D)**	6.40	58	*
LEFT **(E)**	7.78	58	*
TOTAL **(T)**	7.92	58	*

$\alpha = 0.05$

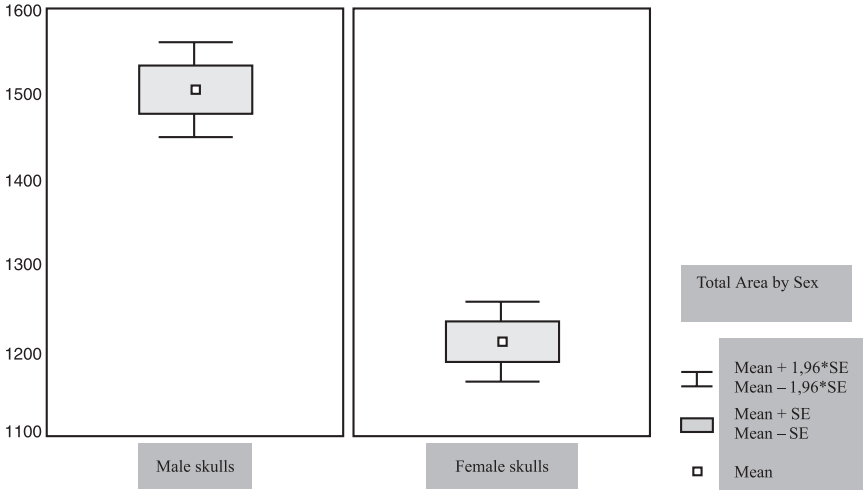

Figure 3 - Means of the total area by sex, with 95% confidence intervals.

metrical points related to the mastoid process is useful in the sexing of skulls.

Since this study was based on anthropometric techniques, it surpasses in importance the older studies such as those of Broca[14], and Martin[15] apud Hoshi[9]. It also improves on the criteria reported by Bass[4], which were based only on descriptive anatomical aspects, as emphasized by Krogman and Íscan[8] .

By using a measurement of surface area, or in other words, by using the result of a product between 2 values, our results improve on those of studies by Schultz[16] apud Helmuth[11], Schäefer[17] apud Helmuth[11], and Keen[18] (1950), which used only a single measurement. Thus, this study is in agreement with the conclusions of Helmuth[11], Schmitt and Saternus[12], and Demoulin[13]. The mastoid region used in this study, being a part of the temporal bone, is recognized as being the most protected and resistant to damage, due to its anatomical position at the base of the skull. This has been demonstrated by Kloiber (1953), Wells (1960), Schäefer (1961), Gejval (1963), and Spence (1967), as cited by Wahl and Henke[10].

Therefore, compared with the most important historical studies dealing with sex determination of skulls, the present study shows important improved results. These results are based on anthroposcopics and anthropometric techniques, and they open paths for further studies based on statistics, which could be of considerable aid to medico-legal investigations.

The required equipment for the execution of this technique is readily available to the majority of medical examiner's offices. Any model of photocopy device can be used.

This technique is easy to execute, offers quick results, and dispenses with any type of special training for the medical examiner.

The technique for sexing skulls presented in this study offers a practical alternative to other methods. This technique meets the needs and realities of the forensic investigation in our country today.

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RESUMO

PAIVA LAS e col. – Determinação do sexo em crânios humanos através do processo mastóide. **Rev. Hosp. Clín. Fac. Med. S. Paulo 58**(1):15-20, 2003.

OBJETIVO: Avaliar a significância da medida da área formada pela projeção xerográfica de três pontos craniométricos relacionados ao processo mastóide, que são, o porion, o asterion e o mastoidale, na determinação do sexo em crânios humanos.

MÉTODO: Foram utilizados 60 crânios, sendo 30 masculinos e 30 femininos. De cada crânio foi realizada uma xerocópia de cada lado sendo assinalados os pontos craniométricos para demarcação de um triângulo. Foram utilizados os valores em mm^3 da área do triângulo de cada lado (D) e (E), e o valor correspondente ao somatório dessas duas medidas (T).

RESULTADOS: A sobreposição dos valores da área direita (D) entre os crânios masculinos e femininos foi de 60%, dos valores da área esquerda (E) foi de 51,67% e dos valores da área total (T) foi de 36,67%. A análise da diferença dos valores, entre os sexos, mostrou ser significativa nas três áreas estudadas. No estudo da área total (T), preferida devido à assimetria entre os lados da crânio, o valor médio para os crânios masculinos foi 1505,32 mm^2, acima do valor máximo encontrado em crânios femininos. O valor médio para crânios femininos foi 1211,24 $mm^{2,}$ abaixo do valor mínimo encontrado em crânios masculinos.

CONCLUSÕES: O trabalho mostra uma significativa diferença entre os valores nas três áreas de estudo, (D), (E) e (T). Os valores da área total (T) apresentam menor sobreposição entre os sexos devendo ser preferencialmente usados na determinação do sexo em crânios. Para a população em estudo, os valores da área total iguais ou superiores a 1447,40 mm^2 significam, com nível de confiança igual ou superior a 95%, pertencerem os crânios ao sexo masculino. Para os valores da área total iguais ou inferiores a 1260,36 mm^2, com nível de confiança igual ou superior a 95%, pertencem os crânios ao sexo feminino.

DESCRITORES: **Medicina legal. Antropologia forense. Antropometria. Mastóide. Características sexuais.**

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