Sex Determination Using Mastoid Process Measurements in Brazilian Skulls

Determinación del Sexo Usando Mediciones en el Proceso Mastoides en Cráneos Brasileños

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SUMMARY: The mastoid process characteristics are of great utility in the diagnosis of sex. De Paiva & Segre (2003) described that sex diagnosis was possible based on the determination of the area of the triangle formed by the points porion, mastoidale, and asterion. The purpose of this study was to determine the existence of sexual dimorphism in the dimensions and the area of the mastoid triangle using statistical and discriminant function analysis. A total of 81 skulls of Brazilian individuals that were part of the Museum of the Federal University of Sao Paulo (UNIFESP) collection were used, with sex and ages known: 50 men and 31 women between 40 and 70 years of age (mean 51.58 years, SD 7.319). Most of the lineal dimensions and the calculated areas were higher in men than in women. Only the distance porion–mastoidale, the area of the right mastoid triangle and the total area, was higher and more significant in men with $p < 0.01$. The analysis of the discriminant function showed that the group of analyzed lineal dimensions presents a low discriminant capacity (Lambda of Wilks = 0.960, Canonical Correlation = 0.199); only porion–mastoidale allowed one to distinguish men's groups from women with a general accuracy of 64.2%, but with a high sensibility to classify men (93%) and a very low sensibility for women (17.7%). These results indicate that the determination of sex based on the dimensions of the mastoid triangle leads to underestimate the women, hence being of less utility in practice.

KEY WORDS: Sexual dimorphism; Sex determination; Mastoid process; Forensic anthropology.

INTRODUCTION

In the skull, the temporal bone is highly resistant to physical damage; thus it is commonly found as remainder in skeletons that are very old; of this, the petrous portion has been described as important for sex determination (Kalmey & Rathbun, 1996).

Paiva & Segre (2003) introduced a easy technique for sex determination starting from the temporal bone, with a small observational error and with a high predictability degree. The technique is based on the triangular area calculation obtained between the points porion, mastoidale, and asterion, measured from xerographic copy of skulls. They found significant differences in the area between the right and left mastoid triangle when comparing male and female skulls, but owing to the asymmetries present in the skulls, it is recommended to observe the value of the total area (adding right and left sides), which was also significant, so that when it is higher than or equal to 1447.40 mm², the skull is diagnosed as male skull, and a value near to 1260.36 mm² or less is indicative of female skull (De Paiva & Segre).

The presence of sexual dimorphism in the mastoid triangle has been recently questioned by some authors (Kemkes & Gobel, 2006), on the basis of the studies of the asterion point localization, which position varies in the course of life (Day & Tschabitscher, 1998); they analyzed the validity in a sample of 197 European mature skulls, indicating that the determination of the mastoid triangle area was a complementary indicator of low value predictive for the sex diagnosis. By means of discriminant function analysis, they described that the indicator was superior for that obtained in skulls from the Institute of Anthropology of Coimbra, Portugal (72% success for female skulls and 60% for male skulls) than those from the Institute of Forensic Medicine, Mainz, Germany (61% success for male skulls and 52% for female skulls).

Considering that the original study of De Paiva & Segre was carried out on a sample of 60 skulls obtained from the Cemetery Necropolis of Guarulhos, Sao Paulo, it is possible to think that the indicator can have an application in the sex determination of the Brazilian population.

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This situation has already been described for other morphologic indicators obtained from South African indigenous skulls, in which it was not possible to determine the presence of sexual dimorphism starting from the classic indicators described by Krogman & Iscan (1986). Other distinctive features were described to evidenciate sexual dimorphism in indigenous South African skulls, some of which were not described for the Caucasian population (Franklin *et al.*, 2005).

With these antecedents, the purpose of this study is to determine the existence of sexual dimorphism in the dimensions and the area of the mastoid triangle, measured directly in the skull, by means of statistical and discriminant function analysis.

MATERIALS AND METHOD

A total of 81 human skulls of Brazilian individuals from the collection of the Museum of the Federal University of Sao Paulo (UNIFESP) were used. All the skulls had a complete registration of sex, age, origin, and cause of death. The skulls that presented trauma evidence or deformations were excluded from this study. The demographic characteristics of the analyzed sample are shown in Table I.

Table I. Demographic characteristics of the sample of 81 skulls of the UNIFESP collection, according to sex.

	N	Min	Max	Mean	S.D.
Male	50	45	65	52.60	5.983
Female	31	40	70	49.94	8.937
Total	81	40	70	51.58	7.319

A quantitative blind study of the dimensions of the sides of the mastoid triangle (Fig. 1) was carried out, using the following points:

Porion (Po): superior point of the external acoustic meatus pore.
Mastoidale (Ma): more inferior point of the mastoid process.
Asterion (As): the meeting point of the lambdoid, occipitomastoid, and parietomastoid sutures.

The points were located and marked by a single investigator on both sides of the skull. Similar to Kemkes & Gobel, lineal measures were directly carried out using a digital caliper (0.01 mm). The mastoid triangle area was calculated by means of the Herón formula. According to the method described by De Paiva and Segre, the total area was calculated by adding the area obtained on each side.

In the case that one of the points of the skull was damaged, it was excluded from the triangle sides mensuration eliminating this area from the sample.

Using the program SPSS 15.0, the descriptive statistics of the lineal dimensions and the mastoid triangle area was calculated; the significance of the mean differences in relation to sex was calculated using t-test ($p < 0.05$).

Fig. 1. Delimitation of the mastoid triangle in the skull of a 56-year-old male belonging to the UNIFESP collection. Po= Porion. Ma= Mastoidale. As= Asterion.

With the purpose to determine if those lineal dimensions allow one to differentiate males and females, the Fischer's lineal discriminant functions were determined.

RESULTS

In the 81 analyzed skulls, most of the lineal dimensions and the calculated areas were higher in males than in females, but in four skulls it was not possible to determine the porion point (Po). Higher values were obtained in females only in Po-Ma, Po-As, and the area of the left mastoid triangle. When contrasting the equality hypothesis among the means, only Po-Ma, the area of the right mastoid triangle and the total area, was higher and more significant in males ($p < 0.01$). The data of the analyzed mensurations are given in Table II.

When carrying out the discriminant function analysis, we found that the group of lineal dimensions analyzed presents a low discriminant capacity (Lambda of Wilks = 0.960, Canonical Correlation = 0.199); only Po-Ma is a variable that allowed one to classify men's groups from women with a general accuracy of 64.2%, but with a high sensibility to classify males correctly (93%) and a very low sensibility for females (17.7%).

Table II. Descriptive statistics and results of t-test of the mastoid triangle, analyzed in 81 skulls of the UNIFESP collection.

	SEX	N		Mean		SD	
		Right	Left	Right	Left	Right	Left
PO-MA	Female	30	31	27.5540	29.7416	2.78468	4.14446
	Male	49	48	30.7245*	29.2281	2.73455	2.73975
MA-AS	Female	31	31	48.3410	50.1752	3.87715	5.18425
	Male	50	49	50.2116	50.2224	4.96235	4.95163
PO-AS	Female	30	31	46.7457	47.5361	3.30104	3.80472
	Male	49	49	47.4553	47.5192	4.43022	3.46695
AREA	Female	30	31	624.08880	685.64443	86.460794	115.934280
	Male	49	48	703.34771*	674.45071	94.316154	92.256915
TOTAL	Female			1296.2241			
AREA	Male			1389.5574*			

Significance level = $p < 0.01$.

DISCUSSION

The analysis of the mastoid process characteristics is important in the determination of sex for forensic purposes. Many authors agree that qualitative aspects, such as their size, ruggedness for muscular inserts, or mastoid process inclination, are very good indicators of sexual dimorphism; however, from the quantitative point of view, their utility is discussed, because, on the one hand, there does not exist consent about the parameters to determine the height, width, or thickness of the mastoid process, which hinders the comparison, and on the other hand, the results in comparable studies have not been conclusive.

This study analyzes the dimensions of the denominated mastoid triangle, defined according to that described by De Paiva & Segre, but measured directly on the skulls. We find differences in the dimensions analyzed in male and female skulls, but these were less marked than those described by De Paiva & Segre in their original article. When supplementing the method with the discriminant function analysis, we find poor discriminant potential of the lineal dimensions used. It is necessary to keep in mind that in the original method of De Paiva and Segre, one obtains the lineal dimensions based on a plane image by means of a xerographic copy of a structure of certain convexity (skulls), which diminishes the distance between the points. Measures obtained with a caliper are also linear measuring a bowstring.

Our results also differ from those reported by Kemkes & Gobel, who obtained values lower than the accuracy to discriminate sex from skulls observing the mastoid triangle; they reported a better sensibility of the method in females.

Based on these antecedents, we conclude that the lineal dimensions and the area of the mastoid triangle is

underestimated in females, being debatable the use of those parameters for sex diagnosis in practice.

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RESUMEN: Las características del proceso mastoides son de gran utilidad para el diagnóstico del sexo. De Paiva & Segre (2003) describieron que era posible el diagnóstico del sexo, en base a la determinación del área del triángulo formado entre los puntos porion, mastoideale y asterion. El propósito de este estudio fue determinar la existencia de dimorfismo sexual en las dimensiones y el área del triángulo mastoideo, mediante análisis estadístico y de función discriminante. Se utilizaron 81 cráneos de individuos Brasileños, pertenecientes a la colección de la UNIFESP, de sexo y edad conocidos, 50 hombres y 31 mujeres, de entre 40 y 70 años (media 51.58 años, DS 7.319). La mayoría de las dimensiones lineales y las áreas calculadas fueron mayores en hombres que en mujeres. Sólo la distancia porion-mastoideale (Po-Ma), el área del triángulo mastoideo derecho y el área total resultaron mayores y significativas en hombres con $p < 0.01$. El análisis de la función discriminante mostró que el conjunto de dimensiones lineales analizadas presenta un bajo poder discriminante (Lambda de Wilks= 0.960, Correlación Canónica= 0.199), sólo Po-Ma permitió clasificar en grupos de hombres y de mujeres con una exactitud general del 64.2%, con una alta sensibilidad para clasificar hombres (93%) y una muy baja sensibilidad para mujeres (17.7%). Estos resultados indican que la determinación del sexo en base a las dimensiones del triángulo mastoideo, tiende a subestimar a las mujeres, siendo de baja utilidad en la práctica.

PALABRAS CLAVE: Dimorfismo sexual; Determinación del sexo; Proceso mastoides; Antropología Forense.

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