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The External Occipital Protuberance: Can It Be Used as a Criterion in the Determination of Sex?

ABSTRACT: Sex determination of a corpse can be problematic in cases where the body is damaged. Useful criteria would assist in the identification of sex in such cases. The goal of this study is to determine the usefulness of the external occipital protuberance (EOP) in the determination of sex, especially in lateral cranium radiographs. The types and configurations of the EOP were investigated on normal lateral cranium radiographs of 1000 subjects (500 males and 500 females) and 694 dry-skull remains (371 males and 323 females) from a 16th Century Anatolian population for the purpose of sex determination. In the radiographic examination, the incidence of less prominent (Type 1) EOP is found to be 85.4% in females whereas 17.8% in males. The spine type (Type 3) EOP is found to be 63.4% in males and to be 4.2% in females. On the other hand, studies of dry-skull remains revealed the incidence of Type 1 EOP to be 67.5% in females and Type 3 EOP to be 55.2% in males. The crest type (Type 2) EOP is approximately equal in both sexes and is found to be less valuable for sex determination in both groups.

KEYWORDS: forensic science, sex determination, cranium, dry skull, lateral cranium radiography

The external occipital protuberance (EOP) is the insertion site of the nuchal ligament and the neck muscles, therefore it reflects shape changes depending upon the power of the stretching neck muscles (1,2). The head has to be held erect by the contraction of the posterior neck muscles. These powerful muscles are true postural muscles and are constantly working to prevent the head from falling forward as a result of gravity (3). The fact that the muscle mass/body weight ratio is less in females than males may be the reason why the EOP is more prominent in males with the accordance of the power of neck muscles (4). In 1875, Broca (5) described the first dimensional and shape changes according to sex differences.

Sex determination of a corpse can be difficult, especially if the body is damaged (decomposition, dismemberment, destruction by corrosives, crushing injuries, etc.) or extremely burned. In such cases, osteological criteria have been developed for the identification of sex. The pelvic bones are the most diagnostic, followed by the skull (6–8). The skull presents well known criteria for sex diagnosis (2,4–10).

There are few studies in the literature pointing to sex differences depending upon the appearances of the EOP (1,5–8). The aim of this study is to determine the degree of usefulness of the EOP in the differentiation of sex, especially on lateral cranium radiographs.

Material and Methods

This study was carried out in two parts. Randomly selected right lateral cranium radiographs of a total of 1000 patients (500 female and 500 male) who were investigated for illness (trauma, sinusitis, abnormal calcification, headache, etc.), but found to be normal were reviewed for the appearance of the EOP in the radiologic investigation group. Radiographs were taken of females and males 25–50 years of age (average age was 36.3 years in females and 38.7 years in males). The EOP was evaluated using a classification system modified from Broca (Fig. 1) (5). According to this classification, subjects showing the smooth form of EOP were classified as Type 1 (Fig. 2), those in whom the EOP was represented as a crest were classified as Type 2 (Fig. 3), and those who had a spine were classified as Type 3 (Figs. 4,5). The assignment of each radiograph to a type was made by the senior author.

The dry-skull remains investigation group consisted of subjects from the 16th century who had lived in central Anatolia. All of the skulls were available from the laboratories of the Department of Paleoanthropology in Ankara University, Faculty of Letters. The skulls were from an archaeological series including postcranial skeletons. Sex of the individuals was determined on the basis of cranial morphology and other criteria (e.g., pelvic morphology, skeletal bone morphology, and archaeological evidence). Dry-skull remains of a total of 694 subjects with known sex (323 female and 371 male) were investigated for the appearance of the EOP using the same criteria implemented in the radiologic investigation.

Chi-square statistical analysis was applied to the data of both investigation groups to determine the difference between sex and EOP types.

Results

The results of the radiologic investigation are given in Table 1. Female subjects were five times more likely to show the smooth form of EOP (Type 1) compared with males. Male subjects were five times more likely to show the Type 3 form of the EOP. In females, Type 1 was found to be 85.4% (Fig. 2*a*) and Type 3 to be 4.2% (Fig. 4*a*). Type 3 was found in 63.4% of males (Fig. 5*a*), whereas Type 1 was observed in 17.8% (Fig. 2*a*). Type 2 EOP was approximately equal in both sexes (Fig. 3*a*). A statistically significant difference was found between sex and EOP types ($X^2 = 492.70$, df$= 2$, $p < 0.001$).

The results of the dry-skull remains investigation are given in Table 2. Female subjects showing the smooth form of EOP (Type

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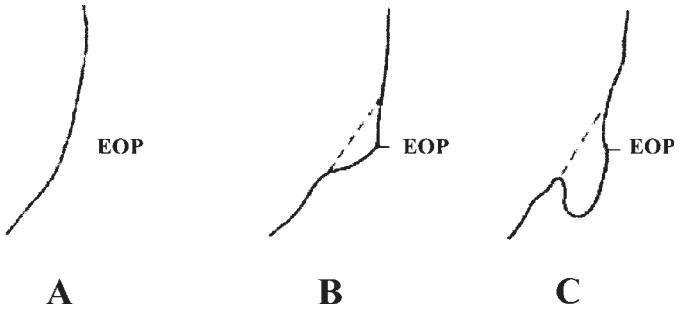

FIG. 1—*Classification of the external occipital protuberance (EOP) modified from Broca (6). A) Type 1: Smooth form of the EOP. B) Type 2: Crest like EOP. C) Type 3: Spine like EOP.*

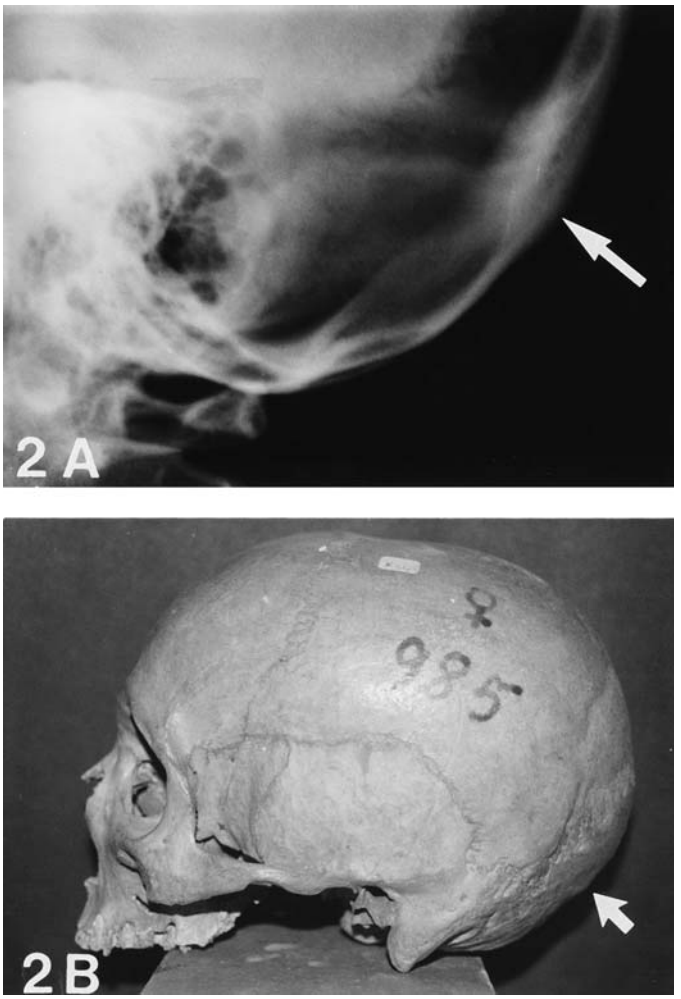

FIG. 2—*Smooth form (Type 1) of the external occipital protuberance (arrow). A) Lateral cranium radiograph. B) Dry skull photograph.*

1) were found to be four times higher than males. Male subjects showing spine type of EOP (Type 3) were found to be six times higher compared with females. In females, Type 1 was found to be 67.5% (Fig. 2*b*) and Type 3 to be 10.5% (Fig. 4*b*). In males, Type 3 was found to be 55.2% (Fig. 5*b*) whereas Type 1 was to be 13.5% (Fig. 2*b*). Type 2 was detected in 22% of females and 31.3% of males (Fig. 3*b*). A statistically significant difference was found between sex and EOP types ($X^2 = 231.492$, df$= 2$, $p < 0.001$).

If present, the spine like protrusion was smaller in females than males in both investigation groups (Figs. 4,5).

Discussion

Forensic scientists and anthropologists are currently able to assess the sex of unidentified adult skeletal remains with high accuracy, depending on the recovered parts of the skeleton. The determination of sex is difficult in cases, involving only fragmentary or incomplete remains and in damaged corpses. Morphologic characteristics and metric methods have been employed for the identification of the sex (1,2,4–11,18). There are also several reports on sex determination by discriminant function analysis of the human skull (12–17). To the current authors' knowledge, this is the first application of lateral cranium radiographs of the EOP appearances to determine sex.

In 1875, Broca (5) reported six different types based upon the appearance of the EOP ranging from the smooth form to the pendant, beaklike form. He determined the smooth form of EOP (type 0) as "hyperfeminen" and the slightly pronounced form (type 1) as "feminen" characteristics. He also determined the crest form of EOP (type 3) as "masculine," the marked (type 4) and very pronounced beaklike form (type 5) as "hypermasculine" characteristics. He stated that the slightly pronounced crest form (type 2) was an "indetermine type"—that it was seen in both sexes equally and could not be used in the differentiation of sex. In the present study, the visual morphologic method was used to evaluate the appearance of the EOP modified from Broca (5). In the radiologic investigation

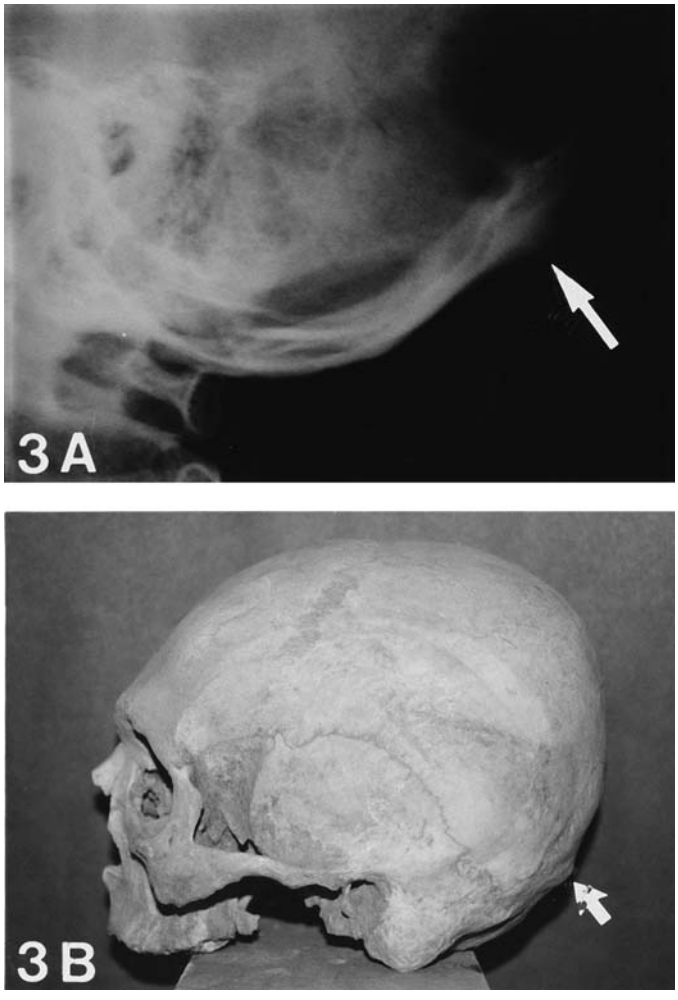

FIG. 3—*Crest type (Type 2) of the external occipital protuberance (arrow). A) Lateral cranium radiograph. B) Dry skull photograph.*

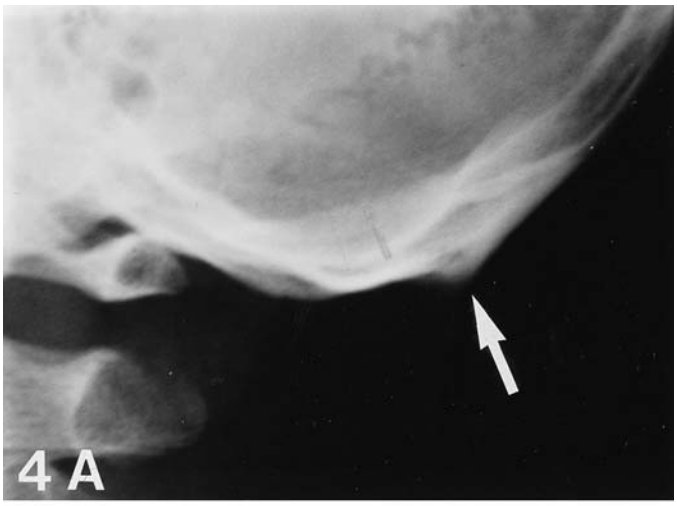

FIG. 4—*Spine like (Type 3) external occipital protuberance (arrow) in a female. A) Lateral cranium radiograph. B) Dry skull photograph.*

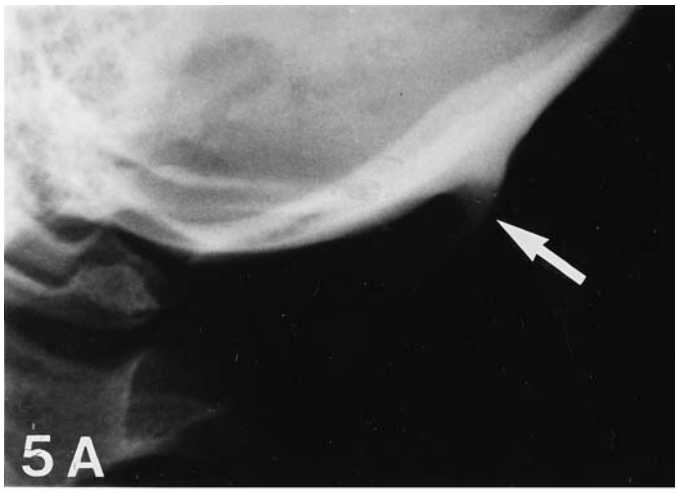

FIG. 5—*Spine like (Type 3) external occipital protuberance (arrow) in a male. A) Lateral cranium radiograph. B) Dry skull photograph.*

group the smooth form of EOP was found to be five times higher in females compared with the spine form which was fifteen times higher in males. On the other hand, the smooth form of EOP was found four times higher in females and the spine form six times higher in males in dry-skull remains. When it occured in females, we observed that the spine-like EOP was smaller than in males in both investigation groups. The crest form of EOP was found approximately equal in both sexes and investigation groups and is therefore not a useful criterion in sex determination.

Olivier (18) measured the thickness of the occipital bone using the reference point of the EOP on 125 French cadaveric skulls. He reported that the EOP was larger in males ($p < 0.001$) and that sexual differences were more easily described than measured.

In an anatomic study, Ebraheim et al. (19) measured the thickness of the occipital bone regions in 52 dry-skulls (25 male and 27 female) to determine screw placement during occipitocervical fusion. Though the primary aim of this study was not the determination of sex, the authors found that the EOP was larger in males compared with females ($p < 0.01$). In a similar study, Zipnick et al. (20) measured the thickness of the occipital bone on various levels. They found that the thickest occipital portion was the internal-external occipital protuberance point and that sex differences were present, but minimal.

TABLE 1—*Distribution of the external occipital protuberance on lateral cranium radiographs according to sex.*

	Female		Male	
Types	*n*	%	*n*	%
Type 1	427	85.4	89	17.8
Type 2	52	10.4	94	18.8
Type 3	21	4.2	317	63.4
Total	500	100.0	500	100.0

($X^2 = 492.70$, df = 2, $p < 0.001$)

TABLE 2—*Distribution of the external occipital protuberance on dry skull remains according to sex.*

	Female		Male	
Types	*n*	%	*n*	%
Type 1	218	67.5	50	13.5
Type 2	71	22	116	31.3
Type 3	34	10.5	205	55.2
Total	323	100.0	371	100.0

($X^2 = 231.492$, df = 2, $p < 0.001$)

It is known that the EOP can show shape differences in various populations. The incidence of a prominent EOP has been reported to be 10.9% in Germans, 8.3% in Asians, 8.3% in Americans, 4.4% in Africans, 1.2% in Egyptians, and 0.0% in Australians (1). The incidence of the EOP is found higher in the Anatolian population (in general, 33.8% in the modern and 32.8% in the historic samples) compared with other populations. As this trait relates to activities and muscle development, physical labor will affect EOP development. Increased physical activity (e.g., to plow arable fields, to reap and carry crops) may explain some of the observed differences.

In conclusion, though the types of EOP can show differences in various populations and are not definitive criteria in the determination of sex, a smooth form of EOP strongly suggests a female identification and a spine form a male identification. Owing to the results of our study, a lateral cranium radiograph can be helpful in the determination of sex in forensic cases where corpses are damaged.

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