INVITED REVIEW

THE WISDOM OF BONES IN THE ASSESSMENT OF SEX FOR FORENSIC MEDICINE

ADLİ TIPTA CİNSİYET TAYİNİNDE KEMİKLERİN ÖNEMİ

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ABSTRACT

The assessment of sex from skeletal remains is one of the most important issues of forensic medicine. There are several methods available, such as morphologic observation, metric analysis, and discriminant analysis of the bones in question. The pelvis is unique in structure, and offers various sex characteristics, which make assessment of sex relatively easy. The skull, mandible, teeth, vertebrae and long bones of the extremities are also used for sex assessment with varying degrees of accuracy.

Key Words: *Skeletal Remains, Assessment Of Sex, Pelvis, Pubis.*

ÖZET

Kemiklerden cinsiyet tayini adli tıbbın en önemli konularından biridir. Morfolojik gözlem, kemik ölçümleri ve kemiklerin istatistiksel karşılaştırmalı analizi gibi çeşitli yöntemler bulunmaktadır. Pelvis yapısı itibariyle cinsiyet tayininde yardımcı olabilecek birçok özelliklere sahiptir. Kafatası, mandibula, dişler, vertebralar ve ekstremitelerin uzun kemikleri de cinsiyet tayininde değişken doğruluk dereceleri göstermektedirler.

Anahtar Kelimeler: *Cinsiyet Tayini, İskelet Artıkları, Pelvis, Os Pubis, Adli Tıp.*

INTRODUCTION

Osteology as such, whether part of human anatomy or forensic medicine, is basically the study of bones, all of which have unique stories to tell revealing clues for the determination of sex, age, status and racial phenotype. This brief review is for those who wish to decipher the meaning and wisdom of bones hidden in the properties of osteology to estimate sex for forensic medicine purposes.

Forensic medicine, also called legal medicine, is a special science that deals with relationships and applications of medical facts and knowledge to legal problems, and by doing so it may also help in furthering the cause of justice. Anatomy, on the other hand, is the study of the structure of the body and the relationships of its constituent parts to each other. Where these two apparently far apart disciplines meet is at the levels of humanity and the well being of humankind. Sound anatomical knowledge of human osteology in the evaluation of death may help to shed light on a large body of legal issues such as sex and age determination, parentage and racial identity. Therefore, it is safe to say that where these two disciplines meet is "The place where death delights to help the living" (HIC LOCUS EST UBI MORS GAUDET SUCCURRERE VITAE).

SEX DETERMINATION FROM THE BONES

Osteology is a common subject for both anatomy and forensic medicine — though its value is now newly appreciated in Turkey as a separate scientific entity in the practice of forensic medicine. The classical methods of osteology in human anatomy may be used well for the purpose of forensic medicine: the human

skeleton is bilaterally symmetrical with an axis to which the upper and lower extremities are joined by shoulder (pectoral) and pelvic girdles respectively. The skull (cranium) is the expanded and modified end of the axis. The bones are generally classified according to their shape as long, short, flat and irregular. However, this classification has no merit and bones must be studied in relation to their function.

The proportion and dimensions of bones show great variations with age and sex within and between racial groups. The study of all these is called anthropometry. Although most anthropometric data are measurements using international techniques based on living subjects or skeletal remains, some data on the presence or absence of a feature (e.g., sagittal crest in Eskimo skulls, preauricular sulcus in female coxae) or the degree of development in certain parts (e.g., frontal ridges) may also be considered as such.

The cranial bones attracted attention first, but later the same methods of metrical properties and/or dimensions were used for all the bones of the skeleton. Many indices were established and used to show differences related to sex, age and race. Such indices may show racial variations, e.g., cranial indices are higher in Mongoloid people than in other races. Observations and measurements for the purpose of the determination of sex, age and race on the skeleton or its parts are useful for anthropology and archeology but are generally essential for the study of forensic medicine.

Estimation of age by skeletal remains may involve many criteria, varying in value depending upon age groups. Dentition and ossification data are highly valuable for such studies. Estimation of sex, on the other hand, is rather easy provided the skeletal remains are postpubertal. Postcranial bones supply better evidence of sex, though pelvic remains are the most reliable for assessing sex.

Forensic osteology is one of the most important disciplines in forensic medicine, and it also plays a significant role in forensic anthropology, which deals with facial superimposition and facial reconstruction research. Although many anatomists may be familiar with the methods of sex and age determination from skeletal remains, in forensic cases one needs to be more accurate, consequently forensic osteologists are required to provide information that may confirm or help to determine the identity of an individual from their remains.

The primary task is to recognize whether the remains are of a human or animal. This is not an easy job to perform; it needs expertise, especially if the remains are small, featureless and fragmented. It is not uncommon for some animal remains to be collected from the scene of a homicide, natural death or a mass disaster/ murder along with human bones. The most distinctive parts of bones, like the ends and/or articular surfaces, may be missing for various reasons. It is at this point that their identification becomes difficult. Once the remains are identified as human then comes the second stage to decide whether those at hand are of forensic or archeological value. The internationally accepted time interval is about 70 years, and beyond this the remains are of no value for legal medicine and are considered archeological. There are several factors that may alter the composition of bones, such as physical conditions (temperature, soil pH, bacteria etc.) and animal/human activities (1). All the factors involved in the decay of bones should be borne in mind before attempting to study a set of bones for biological identity.

Detailed forensic osteology in legal medicine is beyond the scope of this review; however, we herein wish to emphasize the importance of some bones that are frequently studied with high reliability in the determination of sex in forensic medicine.

The assessment of sex from skeletal remains is by far the most important issue for forensic medicine and subsequent determination methods for age and stature are all sex-dependent. When a box full of bones is presented, the very first task of anyone dealing with forensic medicine is to assess the bones in question. By doing so the search, say for a missing person, will be halved once sex determination is completed.

The most sexually dimorphic parts of the skeleton are the pelvis and skull. As Mays and Cox pointed out, sexing accuracy is 98% from the pelvis, 90% from the skull and mandible and 80% from the cranium (2). The human pelvis is unique in shape amongst all other mammals. It has gone through extensive changes during its evolution for two-legged locomotion and to accommodate

large-brained babies. It is expanded from front to back and contracted slightly from the sides so as to create a rounder birth canal. The female characteristics of the pelvis, such as being wider, shallower and having a larger outlet, are reflected in the bony parts that make up the pelvis. Notable examples are a wide, shallow greater sciatic notch and in the comparison between the ala and body of the sacrum, with the width of the former being greater than that of the body of the latter (3,4). Although the pelvis as a whole, the innominate bone (coxa) alone or parts of it as the pubic, ischium or ilium are all very important in sex assessment; however, the pubic bone is the most reliable of all. Nevertheless, it should be remembered that the assessment of sex in isolated and often incomplete remains cannot always be certain.

In general there are three methods available for physical anthropology, archaeology and forensic medicine for the assessment of sex from the pelvis or its constituent parts, and these are as follows: morphological observation, metric analysis and discriminant analysis (5,6). Morphological observations are based on the traits found on the bones. Phenice, in his technical note on sexing the os pubis, claimed that the use of the ventral arch, subpubic concavity and medial aspect of the ischio-pubis ramus as sex determination criteria provided accurate results in excess of 95% (7). This method is simple, time saving and sufficiently objective. Kelly applied Phenice's visual method to an unknown sex population with several other sexing techniques and concluded that this visual method offered well-defined distinctions and reliable sex evaluations (8). On the other hand, Phenice's method was criticized by several authors such as Krogman and Işcan, Lovell and MacLaughlin and Bruce, who all claimed that the sexing accuracy was not as high as Phenice reported (6,9,10).

Some investigators used other traits of the pelvis. Işcan and Derrick introduced a visual technique to evaluate the sacro-iliac joint for sexing, Ali and MacLaughlin examined the auricular surface of the ilium, and MacLaughlin and Bruce used the sciatic notch/acetabular index as a discriminator of sex (11-13). Houghton and Kelly went further and used so-called "scars of parturition" (indication of a female individual who had children) i.e. the pre-auricular sulcus, pitting on the dorsal surface of the pubic body and extension of pubic tubercle, for the identification of a female pelvis (14,15). Suchey et al., however, drew attention to the problem of using such indicators for sex assessment (16).

The size and shape of the pubic bone caught the attention of several investigators in assessing sex. Washburn claimed that the length of the pubic bone was a good indicator of sex (17). Suri and Tandon, in a study on Indian subjects, stated that the ratio of the height and width of the pubic bone was the most reliable criterion for sex determination (18). They also mentioned the characteristics of the ventral arch in females and presence of a diagonal ridge in males as supportive criteria. It is true that the body of the pubic bone is unique; shorter mediolaterally in males with a triangular appearance as opposed to quadrangular in females.

Luo, in an extensive study on 122 adult human pubes, applied discriminant function analysis for determining sex from four pubic measurements, i.e. the angle formed by the midlines of the superior and inferior rami of the pubis, subpubic angle (both in degrees), minimum distance between the symphysial surface and obturator foramen and the minimum thickness of the ischiopubic ramus (both in millimeters). It was claimed that this method was more objective, with high replicability, and its accuracy cannot be obtained by other methods (19).

The bony characteristics of the skull are very useful for assessing sex. Sexual dimorphism shown by the skull is generally related to changes that occur during puberty and are reflected in the increased force of muscle attachments. In the female, the orbits are rounded with less prominent supraorbit ridges and sharper margins. As for the mandible, Loth and Henneberg drew attention to a flexure in the posterior border of the ramus in males, and claimed that the sex can be determined with an accuracy of 94% (20-21). This, however, was criticized by Koski and Donnelly et al. (22-23). They believed that the 94% level of accuracy was highly over-rated.

The mandibles are also very valuable, by using the teeth, for sex assessment. The teeth are capped by enamel, the most durable biological substance known, and possess a core made of a very hard, mineralized tissue called dentine, all of

which make them highly valuable items for forensic medicine (24). Each tooth has its own function and distinctive crown anatomy, which make identification of its place in the dental position easy, i.e. whether it is right or left, upper or lower. The characteristics of the teeth are put to use in sex assessment, as Afşin et al. reported with an accuracy of 85.1% in males and 86.9% in females (25).

Post cranial remains have also been studied for reliable sex assessments. For example MacLaughlin and Oldale examined vertebral dimensions, Holland, Işcan et al. and Işcan and Miller-Shaivitz looked at the tibia, Işcan and Miller-Shaivitz investigated the femur, Holman and Bennett reviewed the humerus and Allen et al. studied the radius (26-32). Dittrick and Suchey investigated a large sample of central Californian prehistoric skeletal remains, and successfully applied the discriminant analysis method and reported about 90% accuracy (33). A similar extensive study was carried out on two different Anatolian population groups from the Middle Ages by Özer et al., who applied statistical and morphological methods. The authors claimed that their study methods were successful in the assessment of sex (34).

Apart from the above-mentioned examples that cover mainly morphologic and statistical measurement based works, newly introduced DNA studies have changed the approach to sex assessment. Hagelberg and Clegg, and Stone et al., by using their molecular genetic technique on ancient human skeletal remains, were able to determine sex correctly (35-36). Smith et al. put forward technical guidelines for sampling dental DNA (37). With this new era of genetic material use, the assessment of sex has become routine and highly accurate in the practice of forensic medicine.

EPILOGUE

The bones have much to tell: as fossilized hominid remains to paleoanthropologists about early humans, as skeletal remains to anthropologists and archeologists about what humans are and especially to forensic osteologists, as remains provide details of individuals at their time of death. The bones, in their properties, offer us indisputable facts — if only we knew how to look at them with keen, questioning, unbiased eyes.

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