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ORIGINAL ARTICLE

Ontogenetic study of the scapula among some Egyptians: Forensic implications in age and sex estimation using Multidetector Computed Tomography

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Abstract *Introduction:* Identification is one of the challenging aspects of forensic sciences. Despite the numerous anthropological researches on the scapula, there is a notable lack of information concerning the scapular growth.

Aim of the work: Aim of the work was to analyze the growth of the scapula by means of thirteen measurements commonly used for assessment among a sample of young aged Egyptian population, in order to evaluate their significance and capacity for age and sex determination during bone development using reconstructed CT images.

Subjects and methods: The study was conducted on 162 Egyptian patients (83 males and 79 females), ranging from birth to 25 years of age, referred to the Radiodiagnosis and Intervention Department, Faculty of Medicine, Alexandria University for Multidetector Computed Tomography (MDCT) of the chest. Thirteen measurements were selected on the scapula and were subjected to statistical analysis.

Results: A significant positive correlation was detected between the measured scapular variables and the age. Significant sexual dimorphism was identified in four of the scapular measurements in the youngest age group. However, significant differences between the sexes appeared after the cessation of growth in girls, where a large number of variables (the scapular length, breadth, maximum length of the spine, supra and infra scapular height, maximum length of the glenoid mass, thickness of the lateral border, as well as the glenoid, supra-infrascapular indices) were sexually dimorphic.

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Conclusions: The results achieved from the current study are useful tools in the diagnosis of age and sex in both forensic and bio-archeological identification procedures; however, further studies are strongly suggested.

1. Introduction

Identification is one of the most challenging aspects of forensic sciences especially in cases where skeletal remains and dismembered or mutilated body parts are recovered and brought for examination. Therefore, it is vital to estimate age, sex, stature as well as ethnic background in order to establish the biological profile of the remains.[1–3] The estimation of age at death in a skeletal collection of immature individuals as well as the determination of sex is quite important during the identity defining stage. The reliability of sex determination depends on the completeness of the remains and the degree of sexual dimorphism inherent in the population.[4]

Methods of age estimation in infants and juveniles either living or dead rely on the degree of skeletal development (length of the diaphysis of long bones of limbs, the closure of epiphyses and the fusion of the primary ossification centers) in addition to dental eruption. Based on the biological (skeletal) age of the individual at the time of death, these methods provide a specific age range derived from the degree of skeletal maturation and growth.[5,6]

Though there is an ongoing debate about whether or not we are able to differentiate between females and males before puberty, there is a general agreement that there are indeed differences between the two sexes before the adolescent growth spurt. However, this sexual dimorphism is minor when compared to adults and therefore it will be more difficult to conclude the sex of younger individuals.[7,8]

To obtain an age at death, it is essential to understand the normal pattern of growth and maturation of every skeletal element and to develop their respective growth models.[9]

Many previous studies have been attempted to focus on postnatal ontogeny of bones (from birth to adult age) in order to determine age and sex. These studies have been carried out on the sacrum,[10] femur,[11] tibia,[12] scapula[13] and innominate.[14–17] Despite these numerous studies, there is a serious lack of information regarding the development of many bones of the human skeleton based on metric measurements in the Egyptian population.

The scapula forms the posterior part of the shoulder girdle. It is a large, flat triangular bone, with costal and dorsal surfaces, three borders (superior, axillary and vertebral), three angles (medial, inferior and lateral) and three processes, the spine, its continuation the acromion and the coracoid process.[18]

The cartilaginous scapula is ossified from seven or more centers. At birth, the body and the spine are already ossified, but not the coracoid process, glenoid, acromion, vertebral border or inferior angle. The coracoid process has two and occasionally three centers of ossification. The first center appears during the first year of life in the center of the coracoid process. The second ossification center appears at approximately 10 years of age at the base of the coracoid process. This second ossification nucleus also contributes to the formation of the superior portion of the glenoid cavity. The two centers unite with the scapula at 15 years of age. A third center can appear at the tip of the coracoid process during puberty and occasionally fail to fuse with the coracoid.[19]

The acromion has two ossification centers (may be three) as well. These centers arise during puberty and fuse together at the age of 22 years. The glenoid fossa has two ossification centers; the first appears at the base of the coracoid process at 10 years and fuses around 15 years of age. It also contributes to the superior portion of the glenoid cavity and the base of the coracoid process, while, the second horse shoe-shaped center arises from the inferior portion of the glenoid during puberty, and it forms the lower three fourths of the glenoid. The vertebral border and the inferior angle of the scapula have one ossification center each, both of which appear at puberty and fuse at 22 years of age.[19]

In recent years, forensic radiology has experienced intensive and rapid progress that is supported by the development of clinical radiology.[20] Virtual anthropology (VA) is best characterized as a multidisciplinary approach to study anatomical data representations in 3D. It is a fundamental tool for anthropological analysis, which allows researchers to deal with problems that could not be solved using traditional anthropological approaches without compromising the integrity of the physical remains.[21]

Since studies conducted on immature bones are scanty with some even outdated, the purpose of this study is to analyze the changes that accompany the postnatal growth of the scapula by means of well-known thirteen measurements commonly used for assessment among a sample of the Egyptian population of a young age range, evaluating their significance and capacity for age and sex determination during bone development using reconstructed CT images.

2. Subjects and methods

2.1. Subjects

The current study enrolled 162 Egyptian patients (83 males and 79 females), who were referred to the Radiodiagnosis and Intervention Department, Faculty of Medicine, Alexandria University for Multidetector Computed Tomography (MDCT) of the chest as part of their clinical workup other than anthropological.

Detailed biographic data including name and date of birth were obtained from every patient.

In order to cover the entire growth period of the scapula up to its whole fusion, the studied individuals were designated in the age range from zero to 25 years, where measurements were executed on the left scapula.

The following exclusion criteria were applied to ensure normal bone evaluation including skeletal immaturity, scapular