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Assessment of adulthood in the living Spanish population based on ossification of the medial clavicle epiphysis using ultrasound methods

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ABSTRACT

It is a fact that in recent years requests have greatly increased to obtain estimates of the legal age of undocumented individuals alleged to be minors who have been forced to enter different European Community countries for socioeconomic reasons or due to war. Spain is one of the countries most affected by this illegal immigration because of its proximity to North Africa. Therefore, it has become necessary to develop new standards which help provide a response to the demands of the justice administration. In recent years, the Superior Justice Court has rejected several pieces of expert evidence on the grounds that the age intervals therein were not sufficiently reliable and that the radiographic techniques used to determine age were invasive, potentially causing harm to the alleged minor. These sentences have caused interest in this field of work to increase within the scientific community. As a result, in order to improve age predictions and, above all, reduce minors' exposure to radiation, this study was created for completion on the Spanish population, using the ultrasound scan as a diagnostic technique. Used as a study sample were the ultrasound images of the proximal sternal epiphysis of the clavicle among 221 individuals of both sexes, of ages ranging from 5 to 30 years. All of the images were classified into 4 stages of fusion, in accordance with the development of metaphyseal closure proposed by Schulz et al. in 2008. The results show differences among the 4 proposed groups for each of the stages of fusion, with the results found in Stage II being especially important because, for both sexes, they would imply that the patient studied has reached an age of over 18 years, which is the legal age of adulthood in Spain, as established by the Spanish Constitution of 1978. Though further research is still recommended, these results, coupled with the use of ultrasound as a non-invasive diagnostic technique, could help solve some of the problems currently arising in justice courts.

1. Introduction

One of the main objectives in forensic anthropology is to determine information about the biological profile of an individual, so as to identify that person as clearly as possible. In this sense, great demands have been made to calculate estimates of the legal age of adulthood of undocumented individuals alleged to be minors who have reached the European Community in recent years. According to UN data, in the last year the number of irregular immigrants to have been detected rose three-fold in Europe [4]. Most of them, coming in from Africa and the Near East, reach the European Community through Italy and Spain, in search of a solution to social conflicts, economic troubles and wars which threaten them in their countries of origin [4].

Throughout this year, 2017, arrivals at Spain's borders across the Western Mediterranean have been far above the figures recorded last year over the same time period [4]. This has led to a problem for the Legal Medicine Institutes in southern Spain, which have to deal with the identification of both the bodies of people who did not reach the Spanish coasts alive and the alleged minors who arrive undocumented on a daily basis.

In this last case, all undocumented individuals must be properly identified upon entering Spanish territory, as established by the current laws in force [2,5,12], and in the case of unaccompanied minors, they may be provided with protective guardians by the Spanish authorities, under the terms established in the legal

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system [2,12,14]. In Spain, a person is defined as being of legal age (adulthood) at the age of 18 years, pursuant to Article 12 of the Spanish Constitution of 1978 [3].

The studies performed are based on the recommendations for estimating age of adulthood among living subjects involved in court proceedings published in the year of 2001 by the German Group for Forensic Age Diagnostics (Arbeitsgemeinschaft für Forensische Altersdiagnostik, AGFAD) [19]. This guide includes a procedure divided into four parts: physical examination of the minor, a radiographic examination of the left hand, external examination of the state of dentition and dental orthopantomography, and a radiographic examination of the sternal end of the clavicle [19].

In order to examine the clavicle the use of computerized tomography is recommended, implementing the fine multislice method [7,8,10,19,23,24,29].

Most of the authors who have completed studies on the time required for fusion of the sternal end of the clavicle agree that the complete fusion thereof takes place at approximately 20 years of age in women and 21 years in men [10,11,17,20,25,26]. However, there is other research which upholds that complete fusion occurs later in both sexes, reaching ages as late as 29 years [27].

Nevertheless, in recent times, because of restrictions on the use of radiation on alleged minors, new techniques are being developed with non-invasive detection methods, such as the ultrasound scan [1,7,8,9,15,16,18,21,22,28]. Studies on fusion of the clavicle have been developed along these lines, based on the hypothesis that finding similar results to the aforementioned might lead to the replacement of techniques based on radiation with non-invasive techniques for the forensic testing of age [17]. Some authors have found fusion times which are very similar to those found using conventional radiography or tomography [19,25]. However, other researchers have faced difficulties when carrying out forensic testing of age, coming up with results that include false positives [8,9].

Despite the discrepancies, all authors highlight the advantages of the ultrasound scan as an inexpensive, fast, environmentally sound, non-invasive technique. However, they all bear in mind that the diagnostic power of this technique is not as great as that of tomography or radiography, because it is only capable of showing the superficial part of the bone, which is why they recommend continued research along these lines, so as to improve the diagnostic technique and accuracy.

Due to all of these reasons, this study has been proposed with the goal of determining the fusion time of the sternal end of the clavicle, using the ultrasound scan as a detection technique, while also evaluating whether it may be used to estimate the legal age of adulthood in Spain.

2. Material and methods

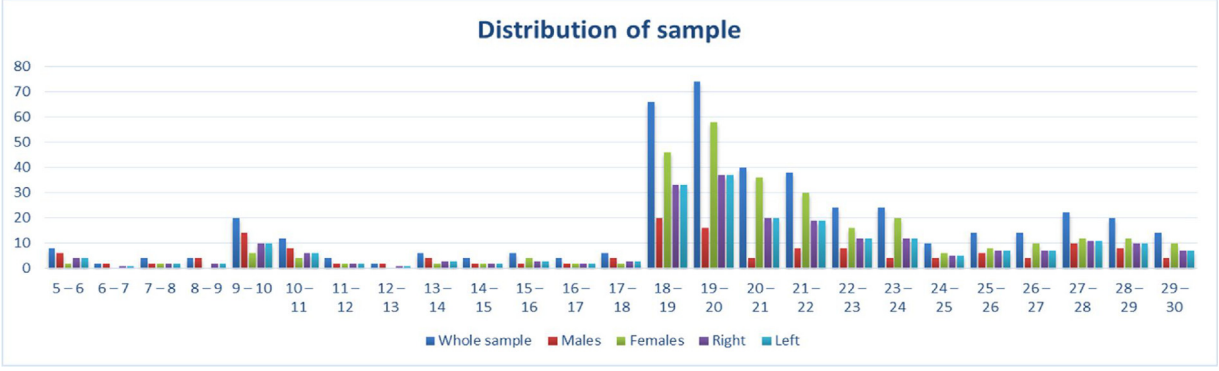
In order to carry out this study, ultrasound images of the sternal epiphysis of the clavicle were used, from 221 individuals selected among Secondary Schools and upper-level Vocational School centers in the Autonomous Region of Madrid. These individuals, who volunteered to take part in the research study, belong to the Spanish population and are of both genders, ranging in age from 5 to 30 years. Prior to taking the ultrasound images, all of the volunteers, or their parents/legal guardians in cases involving minors, signed an informed consent document, which is required under Article 4 of Act 14/2007 of July 3, 2007, the Biomedical Research Act [13].

Both sides of each individual were scanned, left and right, having obtained a total of 442 ultrasound images. Of the individuals, 150 were males (75 individuals) and 292 females (146 individuals). Moreover, because ultrasound was used on both sides, the sample contains 221 ultrasound images of the right clavicles and 221 of the left clavicles (Graph 1).

The research was carried out by the Legal Medicine School's experts in forensic anthropology and legal medicine. In order to take the ultrasound images, a MyLab 60 unit was used in B-Mode format; it includes an LA 523 linear probe with a frequency range of 4–13 MHz. All of the ultrasound images were taken using a probe in a position perpendicular to the tangent line formed by the surface of the clavicle at the level of the sternal region, along both the longitudinal and transversal axes (Fig. 1).

Through the observation of the ultrasound images, and in accordance with the fusion stages established by Schulz et al. in 2008, four states of maturation were identified. However, due to the slight differences founded in the present sample the stages 1

Fig. 1. Position of the probe along the longitudinal axis of the clavicle of a volunteer.



Graph 1. Distribution of the sample (n = 442).