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Short communication

Age estimation of unaccompanied minors Part I. General considerations

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Abstract

In recent years many countries have experienced a sharp increase in the demand for forensic age estimates of unaccompanied minors. In many countries the age thresholds of relevance to criminal prosecution lie between 16 and 22 years.

In line with recommendations issued by the Study Group on Forensic Age Diagnostics, for determining the age of live subjects a forensic age estimate should combine the results of a physical examination, an X-ray of the hand and a dental examination which records dentition status and evaluates an orthopantomogram. To assess the age of persons who are assumed to be at least 18 years old, an additional radiographic or CT examination of the collar bones is recommended.

Forensic age estimates should take account of the ethnic origin and socio-economic status of the person under examination.

Keywords: Forensic age estimation; Unaccompanied minors; Sexual maturation; Hand ossification; Dentition; Clavicle ossification; Ethnicity

1. Introduction

As a result of the global increase in cross-border migration in recent years, in many countries there is a growing number of foreigners who cannot provide documentary evidence for their date of birth. Because of this development, forensic age estimation of unaccompanied minors has increasingly become an integral part of forensic practice. The persons to whom forensic examination is to be applied are foreigners without valid identity documents who are suspected of making false statements about their age. In many countries the age thresholds of relevance to criminal prosecution lie between 16 and 22 years.

In line with the recommendations of the Study Group on Forensic Age Diagnostics, age estimates should consist of a physical examination which also records anthropometric data, signs of sexual maturation and potential age-relevant developmental disorders, an X-ray of the left hand and a dental examination which records dentition status and evaluates an orthopantomogram. To assess the age of persons who are assumed to be at least 18 years old, an additional radiographic or CT examination of the clavicles is recommended [1]. With a view to increasing the accuracy of age estimates and improving the identification of age-relevant developmental disorders, a combination of all methods mentioned above should be used, and each examination should be carried out by an expert with forensic experience. All contributions to the overall age estimate should provide information on the methods or stage classifications as well as the reference studies used for diagnosing age, in addition to the age-relevant findings of each examination. They should also provide the statistical parameters of variation for each feature under examination, along with the diagnosis of the most probable age. The expert in charge of coordinating all contributions should compile the results in a final age diagnosis.

If there is no legal justification for a radiographic examination, the range of possible methods is limited to a physical and a dental examination [2].

Age estimates carried out properly help enhance legal certainty by ensuring equal treatment of persons with or without valid identity documents. On the one hand, they help prevent perpetrators from wrongfully benefiting from false claims to be younger than they really are. On the other hand, they supply exonerating evidence for persons who are erroneously suspected of making false statements about their age [3].

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2. Physical examination

The physical examination includes anthropometric measures such as body height, weight and constitutional type, as well as visible signs of sexual maturity. In boys these are penile and testicular development, pubic hair, axillary hair, beard growth and laryngeal prominence; in girls these are breast development, pubic hair, axillary hair and shape of the hip.

Tanner's [4] staging for adolescence is commonly used to determine the status of genital development, breast development and pubic hair growth. Axillary hair growth, beard growth and laryngeal development may be assessed using the four-stage classification of Neyzi et al. [5]. The four-stage model of Flügel et al. [6] for determining sexual maturity is suitable for purposes of age estimation. On average, girls reach full sexual maturity at the age of 16 years and boys at the age of 17 years.

Of the forensic methods recommended for age estimation, evaluating sexual maturity shows the largest range of variation and therefore should be used for age determination only in conjunction with an evaluation of skeletal maturity and tooth development. However, the physical examination is indispensable to rule out any visible signs of age-related illness and to cross-check whether skeletal age and tooth age correspond to overall physical development.

Most diseases delay development and are thus conducive to underestimation of age. Such underestimation of age would not disadvantage the person concerned. By contrast, overestimating age due to a disease that accelerates development should be avoided at all costs. Such diseases occur very rarely and include endocrinal disorders, which may affect not only the attainment of height and sexual development, but also skeletal development [7]. Endocrinal diseases that may accelerate skeletal development include precocious puberty, adrenogenital syndrome and hyperthyroidism [8].

The physical examination should look for symptoms of hormonal acceleration of development, such as gigantism, acromegaly, microplasia, virilization of girls, dissociated virilism of boys, goiter or exophthalmos. If no abnormality is detected it may be assumed that the probability of such a disease occurring is well below one per thousand [9]. Another indication for a possible hormonal disease is a discrepancy between skeletal age and dental age, as dental development normally remains unaffected by endocrinal disorders [10–12].

3. Radiographic examination of the hand

Radiographic examination of the hand is the second pillar of forensic age diagnostics for the purpose of criminal prosecution.

A basic prerequisite for radiographic age estimation is the above-mentioned physical examination in order to establish whether the proband has a disease that may affect skeletal development, as noted above.

Criteria for evaluating hand radiographs include the form and size of bone elements and the degree of epiphyseal ossification. To this effect, either a given X-ray image is compared with standard images of the relevant age and sex (radiographic atlas) [13,14], or the degree of maturity or bone age is determined for selected bones (single bone method) [15–17]. Various studies have demonstrated that although the single bone method requires more time, it does not necessarily yield more accurate results [18–21]. Therefore, the two atlas methods developed by Greulich and Pyle [13] as well as by Thiemann and Nitz [14] seem to be appropriate for forensic age diagnostics.

The Greulich–Pyle atlas [13] is based on a reference population of the 1930s, whereas the Thiemann–Nitz atlas [14] uses a much more recent study conducted in 1977. With regard to the age interval relevant in forensic terms, Greulich and Pyle [13] identified a standard deviation ranging between 0.6 and 1.1 years for their method. Johnston [22] presented comparable results for the Greulich–Pyle method. The standard deviations identified for the Thiemann–Nitz method range between 0.2 and 1.2 years with regard to the relevant age interval [23].

The skeletal development of hand bones is complete at the age of 17 years in girls and at the age of 18 years in boys.

4. Radiographic or CT examination of the clavicles

To estimate the age of persons who are assumed to be older than 18 years, it is particularly important to evaluate the progress of ossification of the cartilage at the sternal end of the clavicle, because all other developmental systems under examination have completed their growth by this time.

A number of studies are available examining the ossification of the medial epiphysis of the clavicle using either conventional X-rays or CT scans [24–27]. While traditional classification systems differentiate between four stages of clavicle ossification (stage 1: ossification centre not ossified; stage 2: ossification centre ossified, epiphyseal plate not ossified; stage 3: epiphyseal plate partly ossified; stage 4: epiphyseal plate fully ossified), Schmeling et al. [26] divided the stage of total epiphyseal fusion into two additional stages (stage 4: epiphyseal plate fully ossified, epiphyseal scar visible; stage 5: epiphyseal plate fully ossified, epiphyseal scar no longer visible).

If the fusion of epiphyses is complete and an epiphyseal scar is visible, it can be assumed, in the case of women, that the person is at least 20 years old, and, in the case of men, that the person is at least 21 years old. Total fusion of epiphyses with disappearance of the epiphyseal scar was first noted in both sexes at the age of 26 years at the earliest [26].

In a study examining the influence of CT slice thickness on the assessment clavicle ossification, Mühler et al. [28] demonstrated that the slice thickness should be 1 mm to ensure maximum accuracy and diagnostic reliability.

5. Dental examination

Forensic dental age estimation is described in part II of this paper [29].

6. Overall age estimate

The results of the physical examination, the radiographic examination of the hand, the dental examination, and the

radiographic examination of the clavicles, as the case may be, should be compiled by the expert in charge of coordinating all contributions in a final age diagnosis. The overall age estimate should include a discussion of the age-relevant variations resulting from application of the reference studies in an individual case, such as different genetic/geographic origin, different socio-economic status and their potential effect on the developmental status, or diseases that may affect the development of the proband examined, including their effect on the estimated age. If possible, a quantitative assessment of any such effect should be given.

However, for age diagnoses obtained with a combination of methods there is still no satisfactory way to scientifically determine the margin of error. While a number of reference studies collected data on individual features and some studies both on skeletal maturation and tooth mineralization [30–33], there is still no reference study available analysing all required features for a single reference population. If independent features are examined as part of an age diagnosis that combines several methods it may be assumed that the margin of error for the combined age diagnosis is smaller than that for each individual feature. However, it has not yet been possible to quantify this reduction. Combining methods makes it possible to identify statistical outliers, which should also reduce the scale of variation of the overall diagnosis to a certain non-quantifiable extent.

Indirect conclusions about the range of combined overall age diagnoses were possible after verifying age estimates carried out at the Institute of Legal Medicine in Berlin. To this effect, the court's case files of the persons originally examined for age estimation purposes at the institute were consulted to see whether the actual age of these persons was indeed established during the court proceedings. In the 43 cases where the age of the person concerned could be verified beyond doubt deviation between estimated and actual age ranged between plus or minus 12 months [34].

7. The influence of ethnicity on the developmental systems examined

Since the subjects of forensic examination mostly belong to populations for which no reference studies are available that could be used for forensic purposes, the question arises whether there are significant developmental differences between various ethnic groups which would prohibit the application of relevant age standards to members of ethnic groups other than the reference population. In this respect the term 'ethnicity' shall be used only to identify the affinity of various populations in terms of origin.

Comprehensive studies of the relevant literature revealed that the major ethnic groups of interest to forensic age estimation achieve defined stages of ossification, dentition and sexual maturity in the same natural sequence, so that it is generally possible to apply the relevant reference studies also to other ethnic groups [35,36].

Ethnic origin apparently exerts no noteworthy influence on skeletal maturation for the relevant age group. Ossification rates depend primarily on a population's socio-economic status. A relatively low socio-economic status delays development and is thus conducive to the underestimation of a subject's age. Hence, use of the relevant reference studies when examining members of socio-economically less developed populations does not put the person concerned at a disadvantage in terms of criminal law—quite the reverse [35].

There is a relatively small amount of data available on sexual maturity. The temporal sequence of sexual development observed in Asian probands is comparable to that of Europeans, with the exception that Asian males reached the final stage of sexual maturity later. The data available on sexual maturation of African probands are contradictory, which makes further research in this field necessary. It can be said, however, that a comparatively low socio-economic status seems to delay sexual development [36].

To sum up, it can be concluded that forensic age estimates should adequately take into account the ethnic origin and the socio-economic status of the persons to be examined.

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