

Contribution of distal femur MRI to the determination of the 18-year limit in forensic age estimation

Pauline Saint-Martin · Camille Rérolle · Julien Pucheux ·
Fabrice Dedouit · Norbert Telmon

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Dear Editors:

We have read with great attention the article “Forensic age estimation in living individuals using 3.0 T MRI of the distal femur” written by Krämer et al. [1]. In this letter, we would like to comment on the contribution of distal femur MRI to determine whether a male is aged 18 years or more.

For the paper, Krämer et al. conducted a retrospective study on 3.0 T MR scans of the distal femurs of 290 individuals (166 males and 124 females). The evaluation was based on an analysis of T1-weighted turbo spin-echo (T1-TSE) sequences in sagittal orientation. The authors found that the inferior age limit of stage 4, which was defined as follows: “The epiphyseal cartilage is fully ossified, and the epiphyseal scar is visible,” was 18.3 years in males. They stated that stage 4 did not occur in males before the 18th birthday. This is a crucial finding because in forensic age estimation, the search for the “perfect” indicator regarding the 18-year age limit, i.e., the one that would positively allow an expert to distinguish between minors and majors, is always topical.

P. Saint-Martin · C. Rérolle · F. Dedouit · N. Telmon
Laboratoire d’Anthropologie Moléculaire et Imagerie de Synthèse
(AMIS), UMR 5288, CNRS, 37 allées Jules Guesde,
31073 Toulouse Cedex, France

P. Saint-Martin (✉) · C. Rérolle
Institut Médico-Légal, Hôpital Trousseau, CHRU Tours,
37044 Tours Cedex 9, France
e-mail: p.saint-martin@chu-tours.fr

J. Pucheux
Pôle d’Imagerie Médicale, CHRU Tours,
37044 Tours Cedex 9, France

F. Dedouit · N. Telmon
Service de Médecine Légale, CHU Rangueil,
Avenue du Professeur Jean Poulhès,
31403 Toulouse Cedex 4, France

We decided to verify this result with a simple study. We retrospectively reviewed MR scans of the distal femur obtained in the picture archiving and communication system (McKesson Medical Imaging Group, Richmond, BC, Canada) of the radiology department of Tours, France. We selected only males aged between 14 and 20 years over a 5-year period (2009–2013). As usual in this kind of study, subjects were excluded if they had any pathology of the knee (tumor, trauma, infection, or surgical fixation), hormonal disturbance, or general pathology. The socioeconomic status was not taken into account because we had no access to this data. The examinations were performed with a 1.5-T whole-body scanner (Intera, Philips Medical Systems, Amsterdam, The Netherlands). We used a T1-TSE sequence in sagittal orientation. Images were anonymized by deleting the patient’s names and ages, and two observers (PSM and CR) evaluated the images separately and with only one criterion: whether the metaphyseal-epiphyseal junction was totally fused on all images or not. The first observer (PSM) also reviewed each MR scan after 2 weeks. Statistical analysis was performed by R-2.15 [2]. Intra- and interobserver variabilities were calculated using Cohen’s nonparametric kappa test [3].

We included 214 patients. Cohen’s kappa test between the two observers was 0.86. Intraobserver variability was also 0.86. All patients younger than 18 years old were evaluated as incompletely fused. Full ossification first occurred at the age of 18.1 years. Table 1 shows the distribution of the sample by age and the number of individuals with a full ossification of the distal femur for each age.

This study confirms the results of Krämer et al. [1] on a different sample. It strengthens their statement that if a male has a completely fused distal femur on all MR images of a T1-TSE sequence in sagittal orientation, he is at least 18 years old. If the union between the metaphysis and the epiphysis is not complete, no conclusion can be made with regard to the 18-year age limit. One major difference between our sample and

Table 1 Cases by age and sex and a number of individuals with full ossification of the distal femur for each age

	Age (years)							Total
	14	15	16	17	18	19	20	
<i>n</i>	37	45	35	31	32	27	7	214
Complete fusion	0	0	0	0	15	18	6	39

that of Krämer et al. is the use of a 1.5-T MRI for us and of a 3.0-T MRI for them. Krämer et al. stated that a 3.0-T scanner improved the quality of the MRI images and, thus, the examiner's evaluation accuracy. However, it is not the only determining factor because the use of a 1.5-T scanner led to the same result in our study. Krämer et al. also addressed the differences between their study and the study of Dedouit et al. [4], but we think that the use of different weightings—Dedouit et al. analyzed proton-weighted images—makes the results unsuitable for comparison between each other.

In many European countries, the age limit of 18 years is of great importance because it determines majority status. The use of noninvasive imaging techniques has been developed to minimize radiation exposure to the examined individual because the current guidelines recommend the practice of radiographs and a computed tomography when necessary, in

addition to a physical examination [5]. So far, no MRI study has proved to be relevant for the 18-year age limit. The study of Krämer et al. [1] is the first to set a discriminating stage for this threshold. The examination should not be systematically performed as it only concerns males, and it is not useful if the distal femur is not totally fused. However, it confirms that the distal femur is a suitable epiphysis for forensic age estimation and that MRI has a prominent place in this field.

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