Forensic age estimation of living adolescents using MRI of wisdom teeth, wrist and clavicles

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Target Audience: Radiologists and clinicians in the fields of skeletal radiology and pediatrics interested in developmental changes and forensic experts.

Purpose: In the last years the need for forensic age estimations in living adolescents increased with migration particularly from countries where birth dates are not reliably documented. To date age estimation relies on the evaluation of the developmental stages of the third molars, the wrist and the clavicles on the basis of a panoramic X-ray (orthopantomogram) of the jaw, an X-ray of the wrist, and a CT of the sternoclavicular joints. Based on published reference values, the found stages are converted to an age estimate in years. However, the use of ionizing radiation without medical indication is ethically controversial and not permitted in many countries. Thus, an alternative without radiation exposure would be highly appreciated. The aim of the study was to investigate wisdom teeth, wrist and clavicles of the same individuals using MRI to assess developmental differences between the three systems and compare the age estimation to the true chronological age.

Methods: Three subjects per year were randomly selected from a collective (N=203) of 13 to 24 year old healthy males resulting in a group of 36 volunteers (age 13.1-24.4 years, mean 19.0±3.4y) for this study. They underwent a native MRI scan of the jaw, the left wrist and the sternoclavicular joints at 3T (Tim Trio, Siemens AG, Germany) using an 8-channel multifunctional CPC coil (Noras MRI products GmbH, Germany) for the jaw, and a head and neck coil (Siemens AG, Germany) for the wrist and sternoclavicular joints. The following protocol was used: a) for the jaw a 3D PDw TSE restore (TR/TE 172/10ms, 0.6x0.6x1.0mm³) and a 3D T2w CISS (TR/TE 5.41/2.33ms, FA=30°, 0.6x0.6x1.0mm³), b) for the wrist a 3D T1w VIBE (TR/TE 14/4.01ms, 0.9x0.9x0.9mm³) and a 3D T2w DESS (TR/TE 14.28/5.18ms, 08.x0.8x0.8mm³), and c) for the sternoclavicular joints a 2D T2w TSE restore (TR/TE 2905/65ms, 1x1x2mm³) and a 3D T1w VIBE (TR/TE 9.77/3.72ms, 0.9x0.9x0.9mm³). Images of the jaw and the sternoclavicular joints were acquired in supine position; images of the wrist were performed in prone position with outstretched fixed arm. Data of the jaw were assessed by a dentist based on mineralization and eruption stages of the third molars, and reference values for the age in years (i.e., mean and standard deviation, SD) were assigned[1]. Skeletal data were read by a board certified radiologist, and evaluated according to defined stages and reference values[2,3]. The mean estimated age of each body region and the calculated mean of all three regions were compared to the chronological age.

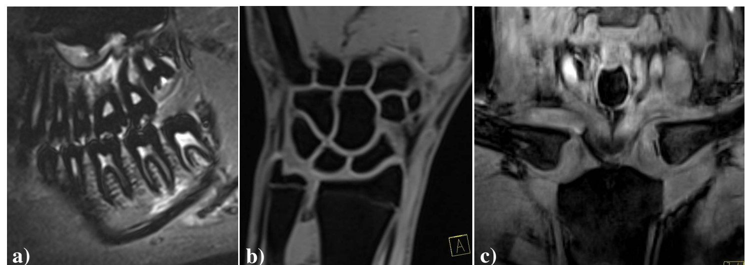

Fig. 1 a) wisdom teeth (3D TSE), **b)** wrist (VIBE), and **c)** sternoclavicular joints (VIBE) in a 17y old male

Results: Fig. 1 shows representative images of the 3 body regions. The estimations based on the development of the wisdom teeth (SD 0.7-1.5 years) and the wrist (SD 0.8-1.3y) agree well with chronological age up to about 19 years, while the older subjects are clearly underestimated (Fig.2 a&b). The noticeable truncation of the estimated values (>19y) based on the wrist (Fig. 2b) is due to the staging system where the development is completed at the age of 19y. The estimations based on clavicles (Fig. 2c) show horizontally distributed estimations at certain ages, e.g., 13.3y, 17.4y, 18.2y etc. which represent the different stages found in the clavicles and correspond to chronological age ranges of up to about 6 years. Although there is less systematic deviation, the greater variability (SD 1.7-2.0y) leads to an increased overestimation and, thus, a misjudgment of minors as adults (red hatched area). Fig. 3 shows the distribution of the differences between mean estimated age (based on all three parameters) and chronological age (mean of differences = -0.4 y, 95% confidence limits, 2.4y and -3.2y). While there is a tendency of overestimation mainly in younger subjects of up to 2 years (one outlier), persons over 18y are rather underestimated.

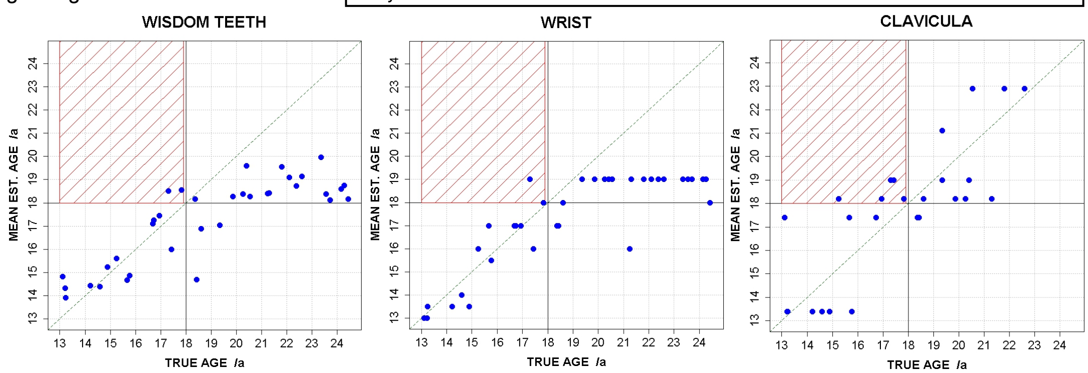

Fig. 2 Estimated vs chronological age based on the developmental of the a) wisdom teeth, b) wrist and c) clavicles (stages 4 and 5 not shown).

Discussion & Conclusion: Age estimations are quite accurate with reasonable variability until a chronological age of about 19 years, whereas older subjects are generally underestimated. In practice, an overestimation of minors is not problematic, provided that the lower 95% confidence limit of the mean estimation based on all systems is lower than the real age. These results showed that a radiation free age estimation based on MRI of three body regions is realistic in the next years, when reference values based on statistically relevant collective are available.

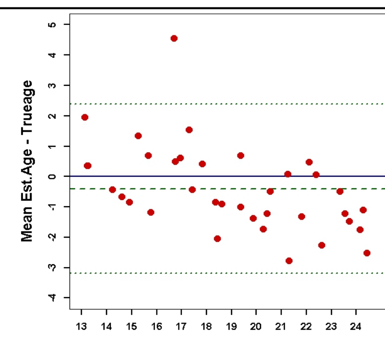

Fig. 3 Distribution of the differences between mean estimated age and chronological age.

References: 1. Scheurer et al. Validation of reference data on wisdom tooth mineralization and eruption for forensic age estimation in living persons. IntJLegalMed 2011;125:707; 2. Greulich et al. Radiographic Atlas of Skeletal Development of Hand and Wrist. 1959; 3. Kellinghaus et al. Enhanced possibilities to make statements on the ossification status of the medial clavicular epiphysis using an amplified staging scheme in evaluating thin-slice CT scans. IntJLegalMed 2010;124:321.