

# Native 3T MRI for skeletal age assessment of the hand and wrist: a comparison of two methods

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**Target Audience:** Radiologists and clinicians in the fields of skeletal radiology, pediatrics interested in skeletal development, forensic physicians and forensic anthropologists

**Purpose:** Skeletal age assessment in living persons is of particular interest in all legal regulations based on age limits. Relevant age thresholds for criminal or asylum proceedings and sports regulations lie between 14 and 21 years. As a standard in skeletal age assessment radiographs of the hand and wrist are evaluated using the atlas of Greulich&Pyle (GP).<sup>1</sup> With increasing migration a rise of the number of age assessments of adolescents has reinforced the debate on the ethically controversial use of ionizing radiation without medical indication constituting the need for X-ray free alternatives such as MRI. A new MRI-based assessment method has been proposed by Dvorak et al. (DV method), which has been applied since 2009 by the FIFA for age estimations in age limited soccer tournaments.<sup>2</sup> Aim of the current study was to investigate the accuracy of both methods by comparison of the chronological and estimated age. Additionally, inter-observer and intra-observer agreement were determined.

**Methods:** Ten subjects per year (n=60), aged 14 to 19 years from a collective (n=220) of healthy Caucasian males were randomly selected. Native MRI scans of the left hand and wrist were performed on a 3T Magnetom scanner (Tim Trio, Siemens AG, Germany) in prone position with outstretched fixed arm using a head and neck coil and a 3D T1 VIBE-sequence (TR/TE 14/4.01ms, 0.9x0.9x0.9mm<sup>3</sup>). Data were evaluated independently by two blinded radiologists according to GP<sup>1</sup> and DV<sup>2</sup>. A consensus reading followed in diverging cases. Age estimates of both methods were compared to each other and to the chronological age of the volunteers, respectively. Intra-observer and inter-observer agreements and the corresponding 95% confidence intervals (CI) were calculated using the intraclass correlation coefficient (ICC) ( $\alpha=0.05$ ) according to Shrout et al.<sup>3</sup>

**Results:** Fig.1 depicts MR images of two participants with different developmental stages. In the Bland Altman plots comparing estimated with chronological age the GP method (Fig. 2 top) showed a slight underestimation of the participants (mean difference -0.43y, limits of agreement as CI [-2.59y; 1.72y]) and no systematic deviation. The DV method (Fig. 2 bottom) resulted in a systematic deviation (mean difference 0.39y, CI [-2.35y; 3.14y]): the age cohort between 14 and 16 years was clearly overestimated while the volunteers aged 18y and 19y were underestimated. Inter-observer agreement was high for both methods with an ICC for GP of 0.96 (CI [0.90, 0.98]) and for DV of 0.91 [CI 0.80, 0.96] while intra-observer agreement was slightly lower (GP: ICC 0.96 [0.94, 0.98], DV: ICC 0.94 [0.91, 0.97]).

**Discussion & Conclusion:** The GP method showed to be quite accurate over the entire age range up to 19 years. The method can be recommended also for a use with MR images as results gained in this study are within the accuracy range of the GP method applied on radiographs.<sup>4,5</sup> A reason for the good results might be that as an atlas based method attention is paid to the age dependent development of numerous growth plates of the hand and wrist. In contrast, the DV method exclusively focuses on the evaluation of a single growth plate, i.e., the distal radial growth plate, and obviously proves not to be applicable for accurate age estimations in the concerned age range. As the use of methods with inherent systematic errors as shown for the DV method leads to considerable errors in asylum procedures and legal proceedings or competitive advantage in sporting competitions, the DV method cannot be recommended. Generally, newly developed methods should be validated prior to use.

## References:

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Fig.1: Examples of coronal MRI (3D T1 VIBE) of the hand and wrist showing different stages of skeletal development at chronological age a) 13.9y, b) 16.2y

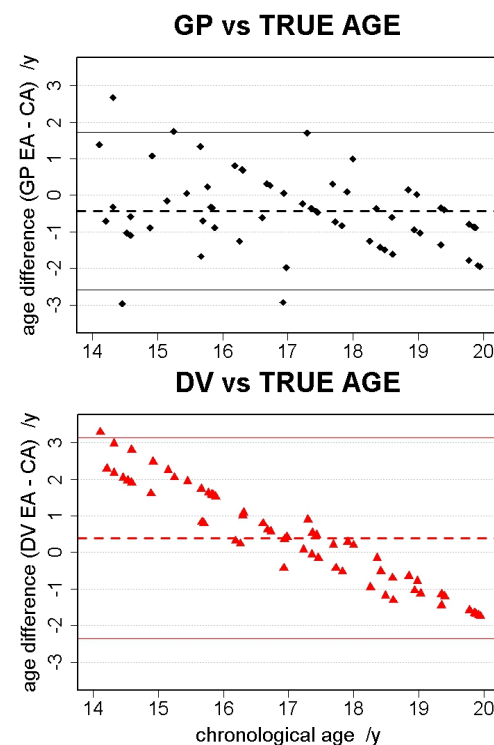


Fig. 2: Bland-Altman plots comparing estimated age (EA) with chronological age (CA). Top: GP method; Bottom: DV method; dashed line: mean; solid outer lines: limits of agreement.