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Age determination by MR imaging of the wrist in Egyptian male football players. How far is it reliable?

Mohammed H. Abdelbary[a,*], Mostafa M. Abdelkawi[a], Merhan A. Nasr[b]

[a] Faculty of Medicine, Helwan University, Egypt
[b] Faculty of Medicine, Ain Shams University, Egypt

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ABSTRACT

Background: Conventional radiographs of the left wrist have been used for assessment of the skeletal age. However, radiation exposure, for this purpose has been considered invasive in the sporting environment.
Aim: To study the reliability of MR imaging of the wrist for estimating bone age in Egyptian young male football players.
Materials and methods: Sixty-one football players between 13 and 18-year-old were recruited. All of them had well known certified chronological age. Coronal Spin-echo T1-weighted images in 3 mm slices were obtained. Three independent raters assessed the degree of fusion of the left radius using a recently developed grading system, composed of six grades.
Results: Moderate correlation between the MR skeletal age with the chronological age in Egyptian young male football players is noticed. Strong interobserver agreement about rating of grade of fusion by MRI has been shown. Moreover, we could build up a regression model for estimation of the players age from grade of fusion by MRI.
Conclusion: Age determination by MR of the left wrist as a radiation - risk free tool provides moderate correlation with the chronological age. A reliable predictive rule for estimation of a player's age from grade of fusion by MRI could be achieved.

1. Introduction

Bone age assessment is required in many clinical situations to assess skeletal development. Accurate evaluation of the individual's age is not only important in pediatric age group to evaluate medical or endocrinal pathologies, but also is greatly requested with increasing immigration, for medicolegal issues and in the field of sports medicine [1]. In the field of sports, there are established age-related tournaments for males and females. For equal chances and fair games to be guaranteed, the biological age as well as the potential aberrations in the maturation of athlete skeletons had to be accurately determined [2].

The most accepted basis for evaluation of skeletal maturity are those of Greulich and Pyle (GP) atlas [3] or the Tanner-Whitehouse method (TW2) [4]. Both methods depend on X-ray radiography to examine the hand and wrist. However, the lack of population-specific atlases is a considerable limitation in applying the currently available GP and TW2 methods. This is because such methods were plotted at a time before considering the vast variety in the skeletal maturation rates between ethnicities and also as a function of nutrition. Nevertheless, updating these methodologies for more optimized population specific use would not be favorable owing to the public concern of the risks of ionizing radiation [5].

MR imaging of the left wrist has been suggested as a highly reproducible tool in determining the skeletal age since it can highlight the anatomical features associated with skeletal maturation without adverse biological effects [6].

The purpose of this study is to evaluate the reliability of MRI as radiation risk- free tool for the assessment of skeletal maturity based on a correlation with the chronological age in young Egyptian football players.

2. Materials and methods

This study is a prospective observational study upon 61 Egyptian healthy male football players, performed between February 2016 and January 2017 at a private practice group. The recruited players were between 13 and 18 years old, where the age was verified by birth certificates and was expressed in years without fractions, so that subjects

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* Corresponding author.
E-mail address: M.H.abdelbary@gmail.com (M.H. Abdelbary).

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who exceeded 6 months of a year would be counted as reaching the upcoming age. Those who did not have a birth certificate were excluded from the study. The study also didn't include those with a history of wrist joint trauma, sprain or surgery as well as those who reported history of genetic, endocrine or metabolic abnormality that might affect bones or joints.

All included participants were informed with the aim of the study, scanning time and environment and were asked to fill up a sheet including their personal data, any medical or drug history as well as a written consent with the aid of their legal guardians.

All participants were scanned using an open permanent magnet extremity MRI device 0.31 Tesla [Esaote®] supplied with an eight-channel wrist/hand coil, where a single T1-weighted SE sequence MRI of the left wrist in coronal plane was obtained for each participant. A single T1-weighted SE sequence MRI of the left wrist in coronal plane was obtained for each participant. The scan was performed in the supine position with the player lying comfortably left hand abducted into the wrist coil.

The scanning parameters used were: [TR 100 and TE 16, FOV 14 cm] with 192 × 160 matrix and 10–14 mm FOV in 3 mm slices. 2–4 Acquisitions and 9 images (to cover the entire distal radius from anterior to posterior). Nine images were printed to include the distal 3 cm of the radius as well as the entire carpal region.

3. Statistical methods

Statistical analysis was done using MedCalc© version 15.8 (MedCalc© Software bvba, Ostend, Belgium). Continuous variables were described in terms of mean, standard deviation (SD), standard error (SE, and 95% confidence limits (95% CI). The grade of fusion by MRI and the actual age at MRI examination were cross-tabulated and presented as counts and percentages. For non-identical ratings by the two raters, the rating was averaged and approximated to whole integers.

Correlation between the grade of fusion and actual age was tested using the Spearman rank correlation. Inter-rater agreement was examined by calculation of the weighted kappa coefficient (k).

Linear regression analysis was used to derive a predictive model for estimation of the actual age from the grade of fusion. Dummy variables were created for the grade of fusion and were entered in the regression model. The performance of the model was assessed using one-way analysis of variance (ANOVA) and calculation of the coefficient of determination (R^2) and adjusted-R^2. P-values < .05 were considered statistically significant.

The images were explored and graded by three radiologists separately. The Grading parameters were published by the British Journal of Sports Medicine. Table 1 and Figs. 1–6 present the classification for grades I–VI for fusion of the physis of the distal left radius.

4. Results

A cross-tabulation at Table 2 clarified the different grades of fusion by MRI, the count of the players in each Grade within the actual age and in relation to the other grades. It has been found that the overall number of players with Grades I, II, III, IV, V & VI were (9,5,12,20,7,8 players) that corresponds to 14.8%,8.2%,19.7%,32.8%,11.5%,13.1% respectively.

Table 1
Classification and grading of ossification/fusion of the distal radius on T1-weighted SE sequence MRI (Quoted from Dvorak et al. [2]).

Grade I	Completely unfused
Grade II	Early fusion: minimal hyper intensity within the physis
Grade III	Trabecular fusion of < 50% of the radial cross-sectional area
Grade IV	Trabecular fusion of > 50% of the radial cross-sectional area
Grade V	Residual physis, < 5 mm on any one section
Grade VI	Completely fused

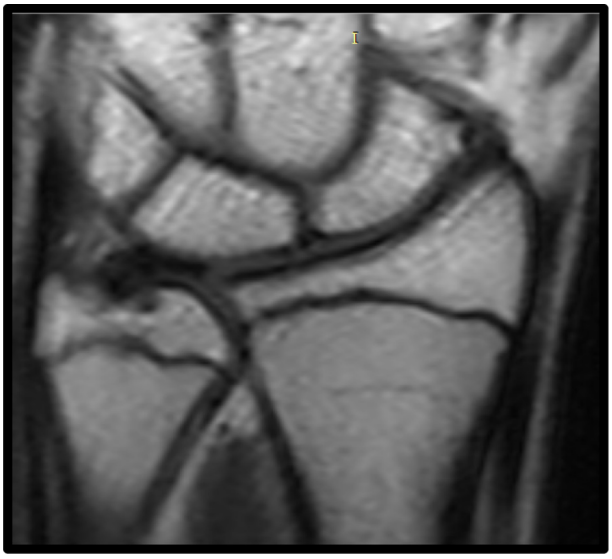

Fig. 1. Grade I; T1 spin-echo WI showing non-fused distal physis of the radius.

Fig. 2. Grade II; T1 spin-echo WI showing minimal fusion based on subtle hyperintensity in the physis [black circle].

In total, 61 players were examined, all the players aged 13 years showed completely unfused distal left radius. Among a total of 8 players aged 14 years, four players showed complete non-fusion (50%), two players (25%) showed early fusion or minimal hyper intensity within the physis while one player (12.5%) showed trabecular fusion of < 50% of the radial cross-sectional area, another player showed trabecular fusion of > 50% of the radial cross-sectional area. None of the players in this age group had shown total fusion.

Regarding subjects aged 15 years, we found that among a total of 25 players, none of them showed non-fusion of the distal radius, 2 players (8%) showed early fusion, 7 players (28%) showed trabecular fusion of < 50% of the radial cross-sectional area, 10 players (40%) showed trabecular fusion of > 50% of the radial cross-sectional area. Incomplete fusion was noted in 4 cases (16%) while complete non-fusion was found in two cases (8%) within the same age group.

Exploring the data from 10 subjects aged 16 years, it was shown that none of them showed non-fusion, one case (10%) showed early fusion, 2 cases (20%) showed trabecular fusion of < 50% of the radial