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Quantification of the Association Between the Apparent Diffusion Coefficient and Age in Normal Pediatric Hips

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QUANTIFICATION OF THE ASSOCIATION BETWEEN THE APPARENT DIFFUSION COEFFICIENT AND AGE IN NORMAL PEDIATRIC HIPS

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Background: The growing skeleton complicates our understanding of how diffusion-weighted imaging (DWI) may add diagnostic value in musculoskeletal disorders. Conventional MRI demonstrates changes in skeletal composition during bone development [1] as the tissue composition at the ends of bone (epiphyses) undergoes a transformation from cellular, highly vascularized hematopoietic marrow to adult marrow containing mainly adipocytes. Several DWI techniques may detect infectious, infiltrative, and traumatic bone disorders in adults. [2,3] However, before DWI may be applied to childhood skeletal disorders, the association between apparent diffusion coefficient (ADC) values for the normal pediatric skeleton and age should be quantified.

Objectives: This study sought to establish a normal curve of the apparent diffusion coefficient over the age range of 0 to 18 years. This curve would ideally then be used as a normal control in the evaluation of abnormal subjects.

Materials and Methods: 11 children (age range 0.2–18.3 years, mean 8.2 years, 7 females) without known hip pathology (e.g avascular necrosis, prior trauma, arthritis, infection, or bone marrow disorder) were recruited for the study under a protocol approved by our institutional review board. Axial images of the femoral head epiphyses were obtained
using a fat-suppressed diffusion-weighted EPI sequence (TR/TE=4300/79 ms; slice thickness=4 mm; matrix=192x144; averages=3) on a 1.5-T commercial whole-body imager (Avanto, Siemens Medical). Mean b-values were obtained by selecting an identical region of interest (ROI) that included the proximal femoral epiphysis on the b1=0, b1=250, b2=500, and b3=750 s/mm2 image data sets. Average ADC values were then calculated as [ln((SIb1/SIb0)/(b1 – b0)) + ... + ln((SIb3/SIb2)/(b3 – b2))]/4. The association between ADC value and age was evaluated with an exponential curve model using non-linear regression analysis. Subjects were classified into two age groups (<10 years, n=6 and 10 years, n=5) and the mean ADC values for the age groups were compared using the unpaired t-test.

Results: A predictable decline in ADC values was observed as age increased. Nonlinear regression analysis with an exponential model described 58% of the variability of the

ADC, R2=0.58 (Figure 1). The mean ADC of 110x10-5 ±19x10-5 mm2/s in the <10 year-old group was significantly higher ($p<0.003$) than the mean ADC of 22x10-5 ±6.4x10-5 mm2/s for the age group 10 years (Figure 2).

Conclusion: The interpretation of an ADC value in the pediatric skeleton has to take into account the age of the patient. Diffusion weighted imaging showed a progressive decline in the ADC value with increasing patient age. This decline in ADC value likely reflected stages of tissue maturation in the femoral head epiphysis from infant cartilage and bone with hematopoietic marrow to adult-type trabecular bone with fatty marrow. In addition, this age-based dataset of normal ADC values may be used as a reference standard to identify and quantify DWI abnormalities in pathologic hips.

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