Early bone marrow conversion in adolescents with Anorexia Nervosa: A T1 Relaxometry Study

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Introduction: T1-weighted imaging of the knees of adolescent girls with anorexia nervosa (AN) has been found to show consistently higher signal intensity and greater homogeneity in the femur and tibia as compared to normal adolescents, who typically exhibit striations and regions of lower signal, representing hematopoietic marrow. We performed T1 relaxometry measurements on a cohort of adolescent girls with AN as well as age-matched controls to study this phenomenon. The use of an extremity scanner led to higher subject recruitment rates since the patient population with AN tend to have high rates of anxiety and claustrophobia.

Materials and Methods: We enrolled 10 girls with AN and 10 healthy age-matched controls, age 14-19 yrs, mean 16.68 yrs, from our adolescent clinic. Controls were within 2 years of the chronological age of the patients, and at the same Tanner pubertal stage. IRB approval and informed consent was obtained.
MR imaging was performed on a 1.0 T extremity scanner (ONI Medical Systems, Wilmington, MA). T1 relaxometry acquisition consisted of seven FSE acquisitions of varying TR (350-3000 msecs) with a fixed TE of 17 msecs, spanning the knee of the subjects. T1 maps were generated using a two-parameter-fit iterative algorithm (based on the assumption of monoexponential T1 relaxation processes) using IDL (ITT Visual Information Systems, Boulder,CO).
Visual inspection of the T1 weighted images in the control subjects revealed as consistent pattern of lower signal intensity (Fig 1) – presumed to be residual red marrow – within the medial aspect of the distal femoral metaphysis and the central aspect of the proximal tibial metaphysis, in accordance with previously reported studies (1). Adolescents with AN, on the other hand, showed higher signal intensity in these anatomical locations as seen in Fig 1. The epiphyses, both femoral and tibial, were uniformly high signal intensity in all subjects, presumed to be yellow marrow. Hence regions of interest were placed in these locations and mean T1 values recorded (ImageJ, NIH, Bethesda, MD). The anatomical location of the ROI was consistent for all subjects.

Results: A factorial ANOVA analysis of the mean T1 in the 4 ROIs chosen was performed using SAS/STAT (SAS Institute Inc., Cary, NC). The model was adjusted for pair matching, for intra-subject correlation among sites, and for age, which proved to be the strongest influence ($p=0.004$). Mean T1 in the two metaphyseal locations showed a decrease of 50 msecs in the T1 for adolescents with AN as compared to controls ($p=0.04$). Within the epiphyses, the T1 values were consistently lower than within the metaphyses ($p<0.0001$) but not significantly different between the AN and control groups ($p=0.35$).

Discussion: This study shows that adolescent girls with AN exhibited higher fatty marrow content within the metaphyses about the knees consistently as compared to age-matched controls even when T1 values were sampled at fixed anatomical locations. This suggests earlier, and perhaps more widespread, red to yellow marrow conversion than identified by visual inspection of T1 weighted images alone. Future plans include a more comprehensive histogram analysis on a larger cohort of subjects.
This study also demonstrates the feasibility of using a 1.0 T extremity scanner for relaxometry studies in the musculoskeletal system. This is a particularly important finding for studying patient populations with psychiatric disorders such as AN since they tend to exhibit anxiety and claustrophobia in conventional MR scanners.

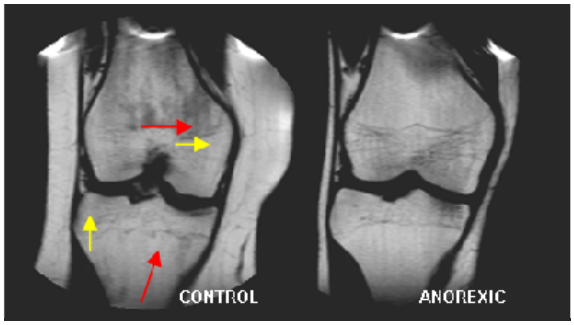

Fig 1: T1-weighted images (TR/TE=350/17 msec) from an anorexic and age-matched control showing lower signal intensity in red marrow in control. Red and yellow arrows indicate regions chosen for ROIs representing red and yellow marrow respectively.

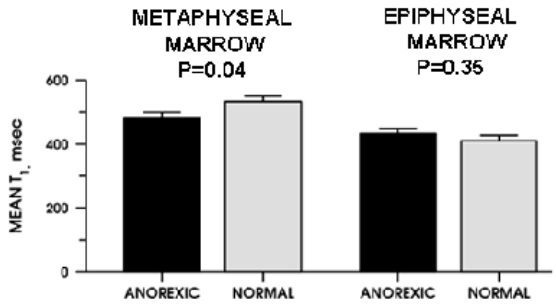

Fig 2: Factorial ANOVA analysis of mean T1 of metaphyseal red marrow and epiphyseal yellow marrow shows a statistically significant difference in the red marrow ($p=0.04$) but not in yellow ($p=0.35$)

References:

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