Quantitative Measurement of Bone Marrow Composition and Bone Structure Using Simultaneous Acquisition of Fat Fraction and T2* with Multiple Gradient Echo images

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Introduction

MR imaging is an ideal technique for non-invasively studying bone marrow cellularity in the spine. While marrow composition has been inferred qualitatively from MR appearance, there are a few quantitative studies directly measuring the two constituents of fat and water [1,2]. In addition, the method we present here is able to provide the rate constants, T2*. T2* values are sensitive to local magnetic susceptibility arising from the interface between trabecular bone and bone marrow [3].

Here, we illustrate its use for measuring lumbar spine of fat fraction and T2* in normal volunteers.

Materials and Methods

The study included nine normal volunteers ranging in age from 23 to 48 years old without any medical histories of fracture, hematological disease, malignant disease or irradiation. MR imaging was performed on 1.5T whole-body imager (Nova Dual, Philips Medical Systems). The pulse sequence generates gradient echoes at TE = 2.3, 4.6, 9.2, 13.8, 18.4, 23.0, 27.6, 32.2, 38.8, 43.4 and 48 msec. Then the real image of the first echo was used to differentiate between the areas above and below the 50 % fat fraction. The last ten in-phase echoes were used for measuring bone marrow T2*. The imaging parameters were TR= 500m sec, a field of view of 38x38cm^2, matrix= 256x256, slice thickness=10 mm, flip angle=12 degree. Lumbar region were scanned in sagittal plane using phased array coil. Data were reconstructed on-line workstation yielding fat fraction, water fraction and T2* images due to the real image differentiating fat fraction and the effects eliminating the T1 effect. The region of interest (ROI) was measured at lumbar vertebrae excluding the cortex at the L3 vertebrae. In order to assess the accuracy of the fat and water fraction, localized MR spectroscopy (MRS) using the standard STEAM sequence was performed in the same location. Mean and SD of fat fraction and T2* were calculated from ROIs (80-150) pixels) by using same ROI's in the lumbar spine. Fat fractions of multiple gradient echo images (MGE) vs. MRS, and T2* vs. aging change were analyzed by linear regression using commercially available software (JMP, SAS Institute Inc.).

Results and Discussion

Typical fat fraction and water fraction images were shown in Fig. 1. The mean fat fraction and T2* values for L3 vertebra were (mean+/-SD): Fat fraction: (48.8+/-14.5 %) and T2*: (12.3+/-2.3 msec). Fat fraction values of MGE vs. MRS show very good agreement (R^2 =0.94) in Fig. 2. T2* values vs. aging change for the lumbar spine showed negative linear correlation (R^2 =0.74) in Fig. 3. Negative linear correlation change of T2* with age is compatible with the past report [4].In summary, MR determination of those parameters could be used to assess and diagnose a deficiency in marrow composition and bone structure using fat fraction and T2*.

References

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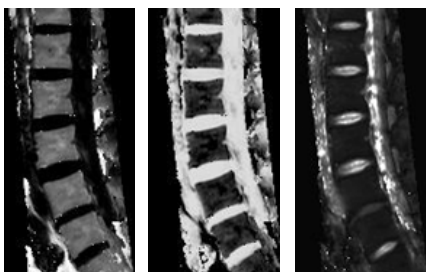

(a) (b) (c)

Fig. 1 A 41-year old female of normal volunteer (a) Fat fraction image (b) Water fraction image (c) T2* image

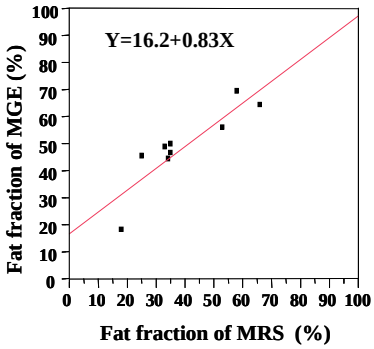

Fig. 2 A comparison of fat fraction

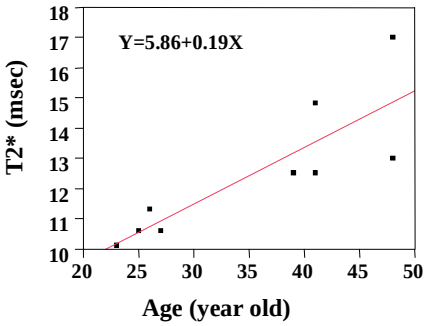

Fig. 3 T2* value vs. aging change