Preliminary in-vivo bone quantification results using MR and pQCT

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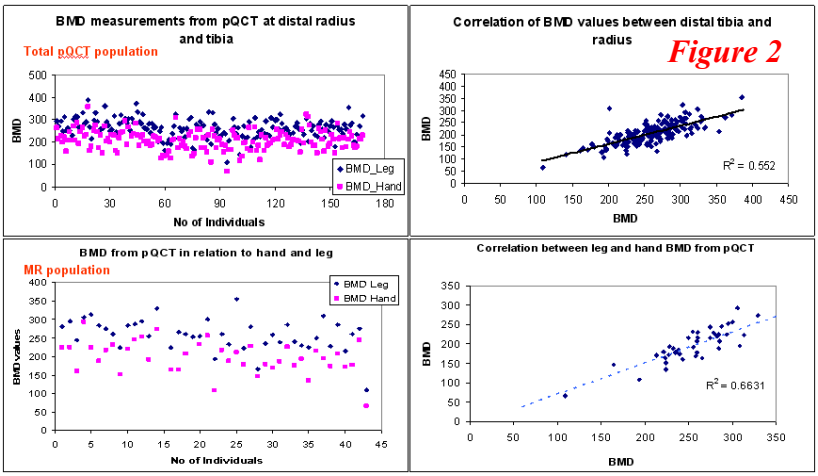
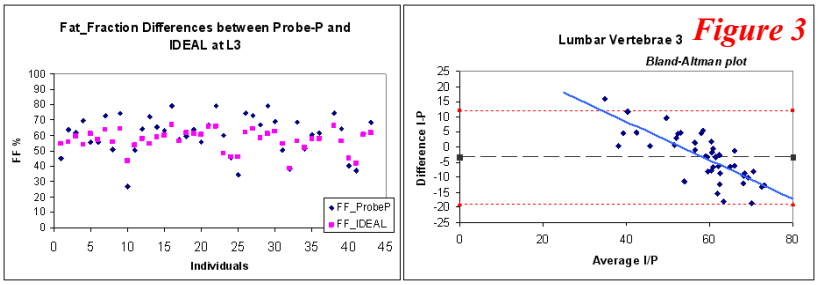
Introduction: Bone quantification is commonly measured using Dual Energy X-Ray Absorptiometry (DEXA) and peripheral Quantitative Computed Tomography (pQCT) *Figure 1*. Magnetic Resonance Imaging (MRI) and Magnetic Resonance Spectroscopy (MRS) research have shown promising potential in the quantification of bones. Our work was based on using these ideas in a clinical setting on individual patients. The work was involved in a High Bone Mass (HBM) study program to identify individuals affected with a genetic condition of low-density lipoprotein receptor related protein–5 (LRP–5). pQCT data was collected from 169 individuals from the HBM study. 43 people were selected for MRI and MRS acquisition from the total pQCT population.

Materials and Methods: A 3.0 Tesla whole-body GE Signa system (HDx then MR750) was used to acquire MRI data from distal leg, wrist and lumbar vertebrae, and MRS data from lumbar vertebrae only, in 43 individuals with HBM. A three point Dixon technique (IDEAL) was used to acquire separate water and fat images to analyse fat-fraction (FF = fat signal / sum of fat signal and water signal). High resolution T_1 images were acquired to study the trabecular structure to calculate the bone volume fraction (BVF = bone map / sum of bone map and trabecular map) and ^{1}H single voxel point-resolved unsuppressed spectroscopy (PRESS) were acquired on individual vertebrae. pQCT measurements of bone mineral density (BMD) were acquired using a XCT-2000 Stratec scanner *Figure 1*. In-house software was developed (using MATLAB) to process these images and perform a variety of structural and composition measurements in one user-friendly environment, enabling the additional benefits of MRI to be critically evaluated. Spectra were processed using the linear combination LCModel.



Results: BMD values from pQCT at distal radius and tibia have been measured from the total pQCT population and from the MR population of 43 individuals. This data is described in *Figure 2* (top & bottom). The BMD from the pQCT population has a correlation of around 55% (R^2 = 0.552) between hand and leg *Figure 2* (top right) and the MR population has a correlation of around 66% (R^2 = 0.663) between hand and leg *Figure 2* (bottom right) which shows a very good relationship of BMD between each other. FF was later calculated using IDEAL image data and spectroscopy data from the total MR population. FF was compared between the two techniques at identical vertebrae locations of L1, L3 and L5. *Figure 3* describes the FF data from L3 vertebrae as a comparison between IDEAL and spectroscopy. *Figure 3* (right) is a Bland-Altman plot describing the comparison between the two methods of FF quantification. The initial results from the Bland-Altman plot illustrate a non-random difference between the two methods of FF estimation. Work is ongoing to study this difference.



Conclusions: MRI and MRS show promise in measuring bone properties. Software has been successfully developed which permits an effective evaluation of this potentially useful modality for in-vivo bone studies. In the future, further image analysis tools could be incorporated including textural analysis and could be used to measure bone properties on a regular basis. Work is ongoing to further enhance these data for a better and accurate quantification of bones.

References: 1. G.P. Liney, *et al.*, *JMRI* 26:787-793 (2007)
2. P.Gibbs, *et al.*, *MRM* 50: 92-98 (2003)
3. V.R. Lazar, *et al.*, Poster for *BC-ISMRM* (Cardiff), Sep 2009