Rathnayaka, Kanchana and Coulthard, Alan and Momot, Konstantin I. and Volp, Andrew and Sahama, Tony R. and Schuetz, Michael and Schmutz, Beat (2010) ***Improved image contrast of the bone-muscle interface with 3T MRI compared to 1.5T MRI*** [Abstract]. In: 6th World Congress on Biomechanics, 1 - 6 August 2010, Suntec Convention Centre, Singapore.

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Submitted on
Friday, March 12, 2010
For 6TH WORLD CONGRESS ON BIOMECHANICS
Submission ID : WCB-A00732-01594

Presentation Type : Oral
Topic/Symposium : Track 6.6 - Biomedical Imaging and Optics
Keywords : 3T MRI, Long bones, Image segmentation

Improved image contrast of the bone-muscle interface with 3T MRI compared to 1.5T MRI

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Virtual 3D models of long bones are increasingly being used for implant design and research applications. The current gold standard for the acquisition of such data is CT scanning. Due to radiation exposure, CT is generally limited to the imaging of cadaver specimens. MRI does not involve ionising radiation and therefore can be used to image selected human volunteers for research purposes. The feasibility of MRI as alternative to CT for the acquisition of morphological bone data of the lower extremity has been demonstrated recently [1]. Some of the current limitations of MRI are long scanning times and difficulties with image segmentation in certain anatomical regions due to poor contrast between bone and surrounding muscle tissues. Higher field strength scanners promise to offer faster imaging times or better image quality. In this study image quality at 1.5T is quantitatively compared to images acquired at 3T.

The femora of five human volunteers were scanned using 1.5T and 3T MRI scanners from the same manufacturer (Siemens) with similar imaging protocols. A 3D flash sequence was used with TE = 4.66 ms, flip angle = 15° and voxel size = 0.5 × 0.5 × 1 mm. PA-Matrix and body matrix coils were used to cover the lower limb and pelvis respectively. Signal to noise ratio (SNR) [2] and contrast to noise ratio (CNR) [2] of the axial images from the proximal, shaft and distal regions were used to assess the quality of images from the 1.5T and 3T scanners. The SNR was calculated for the muscle and bone-marrow in the axial images. The CNR was calculated for the muscle-cortex and cortex-bone marrow interfaces, respectively.

Preliminary results (one volunteer) show that the SNR of muscle for the shaft and distal regions was higher in 3T images (11.65, 17.60) than 1.5T images (8.12, 8.11). For the proximal region the SNR of muscles was higher in 1.5T images (7.52) than 3T images (6.78). The SNR of bone marrow was slightly higher in 1.5T images for both proximal and shaft regions, while it was lower in the distal region compared to 3T images. The CNR between muscle and bone of all three regions was higher in 3T images (4.14, 6.55, 12.99) than in 1.5T images (2.49, 3.25, 9.89). The CNR between bone-marrow and bone was slightly higher in 1.5T images (4.87, 12.89, 10.07) compared to 3T images (3.74, 10.83, 10.15). These results show that the 3T images generated higher contrast between bone and muscle tissue than the 1.5T images. It is expected that this improvement of image contrast will significantly reduce the time required for the mainly manual segmentation of the MR images. Future work will focus on optimizing the 3T imaging protocol for reducing chemical shift and susceptibility artefacts.

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