Real-time Tagging of Muscle Dynamics in a 70cm Bore 1.5T Scanner

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Purpose The purpose of this work was to test the ability of a "wide bore" (70cm diameter), 1.5T MR system to perform real-time tagging of skeletal muscle dynamics during leg motion through full extension and flexion of the knee.

Background MR motion tracking is especially suited for motions that are repeated, such as cardiac contraction. MR tagging and CINE-PC has been shown previously to have great potential for characterizing *in vivo* musculoskeletal motion [1-3]. However, the range of possible limb motions has been limited by the small bore size of 1.5T MR systems, and the need for repeated motions limits the type of loads that can be applied. Therefore, real-time tagging in the wide-bore scanner will enhance the study of musculoskeletal motion and mechanics under physiologic conditions. We present results from real-time tagging images of the thigh musculature during a full flexion-extension of the knee (motion not previously possible at 1.5T).

Method A real-time pulse sequence developed for interventional MRI [4,5] was modified to apply tagging pulses interactively with a mouse-click. For the data shown in this abstract the following parameters were used: scanner: Siemens Espree, SSFP, TR=3.5ms, TE=1.75ms, flip angle=30 degrees, bandwidth=600 Hz/pixel, matrix = 64 phase x 160 readout points, ½ NEX in phase encode, FOV = 225 x 450 mm, slice thickness = 6mm, tag spacing 15mm, body matrix coil. The anterior portion of the body matrix coils was held in place over the thigh during the motion. This gave approximately 10 frames per second time resolution. The imaging slice was prescribed in a double oblique orientation along the femur. While performing the extension and flexion of the knee, the volunteer was able to watch the real-time images on an in-room display to time the application of tagging, or time the motion of the leg.

Results The tags were visible for approximately 800-1000ms in the real-time images (~10 time frames). This was sufficient to visualize the strain in skeletal muscle groups during motion. The tags reflect the action of each muscle group. That is, as the knee flexes, the knee extensors lengthen and the knee flexors shorten. Similarly, as the knee extends, the knee extensors shorten and the knee flexors lengthen. Additionally, the tags highlight the complex motion of the muscles, where in the quadriceps muscles, the tags not only stretch/shorten but they also undergo shear deformations.

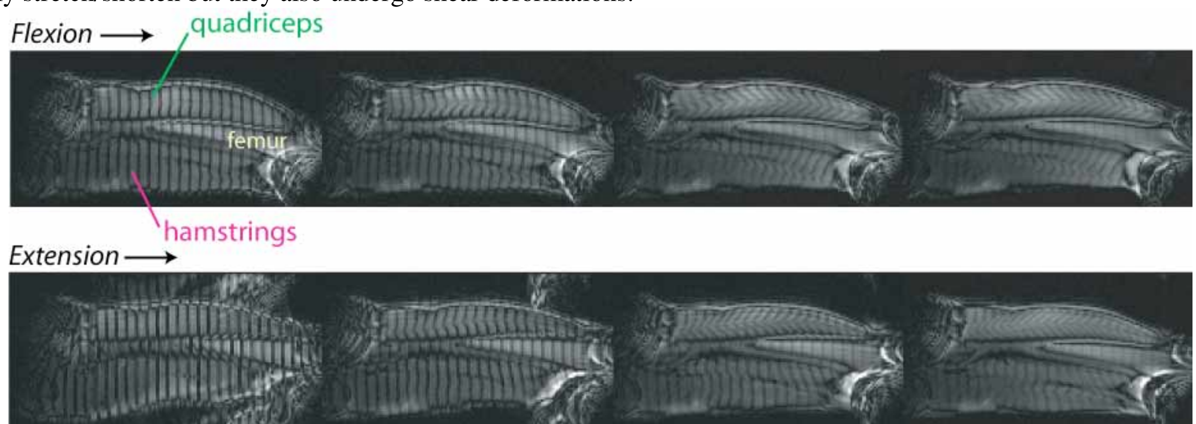

Figure 1: A sequence of 8 images from every 2nd frame of a real-time movie showing the deformation of muscles in the human thigh during knee flexion (top row) and extension (bottom row). The quadriceps muscle group (knee extensors) is on the top (anterior) side of the image, and the hamstrings muscle group (knee flexors) is on the bottom (posterior) side of the image. The tags placed in the quadriceps muscles show that the muscles not only stretch/shorten, they also undergo shear deformations.

Conclusions and Discussion Even with the reduced gradient switching speeds of the "wide bore" scanner, it was possible to achieve 10 frames/sec real-time tagging for imaging muscle mechanics with a large range of motions. It will be possible to increase the temporal resolution by a factor of at least two with the application of specialized array coils and TSENSE accelerated imaging. This development has direct application to advancing our understanding of the complex contraction mechanics of muscles under physiologic motions and loading conditions.

Citations **1**. Stone, M. et al J Acoust Soc Am. 109(6):2974 (2001) **2**. Drace et al. JMRI 4:773 (1994) **3.** Sinah et al JMRI 20:1008 (2004) **4**. Guttman et al Circulation. 108 (17): 429 (2003) **5**. McVeigh et al Acad Radiol. 12(9):1121 (2005)