**Dynamic Functional Imaging of Quadriceps and Hamstring Muscles under Isometric and Active Extension-Flexion Contraction.**

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**Purpose:** Musculoskeletal conditions such as knee osteoarthritis are associated with quadriceps atrophy and weakness [1] while Duchenne muscular dystrophy is associated with fat infiltration of the quadriceps [2]. A detailed understanding of the dynamics of quadriceps femoris and hamstring muscles will be a valuable clinical tool to evaluate association of muscle function with disease conditions such as osteoarthritis and dystrophy.

**Aim:** To develop methods to quantify velocity and strain rate changes in different muscle groups of the thigh during knee isometric and extension-flexion contractions using an MR compatible computer controlled servo-motor driven device.

**Methods:** The upper leg extension-flexion device was driven by a computer-controlled, motorized hydraulic actuator, allowing clamping at any angle of flexion [Fig. 1]. Two optical force transducers mounted on carbon-fiber plates, could be used either for active extension or flexion contractions or for stroke or dystrophy patients who cannot flex on their own. Five (IRB approved) subjects, laying prone on a 1.5-T GE whole-body scanner, were scanned with a phased array cardiac or torso coil, while performing isometric or active extension-flexion contractions (at 40% MVC) synchronized to an audio cue. The imaging trigger was derived from the output of the force transducer allowing gated acquisition synchronous with the contractions. The output was also projected on a screen for visual bio-feedback. A gated VE-PD-C (water) imaging sequence (16.5 ms TR, 7.7 ms TE, 20° FA, 122Hz/pixel bandwidth, 10 cm/s velocity encoding in three directions, 4 views/segment, 22 phases, 2 excitations, 154x256-mm image matrix, 300x180-mm FOV, 1 slice, and 2:44 min scan time) in sagittal and axial orientations was used to acquire tissue velocity encoded dynamic images of all the thigh muscles. Velocity and 2D Strain rate (SR) tensor was calculated in 2D after the phase images were corrected for phase shading artifacts from the symmetric part of spatial gradient of velocity vector field.

**Results:** Axial PC images and corresponding velocities plots in the SI direction, as a function of active extension-flexion cycle, at 0.33 and 0.66 of femoral length, with ROI’s indicating vastus lateralis, intermedius, rectus femoris, sartorius and other muscles of the thigh, are shown in Fig.2-A,C with corresponding numbered plots in B,D. The synergistic and antagonistic muscle groups can be distinguished by the opposing velocity directions in Fig. 2B and D. Importantly, heterogeneity of velocity pattern and hence strain distribution is observed not only in the axial plane but along S/I direction of the femur by comparing 2-A,B with 2-C,D. The sagittal image positioned to capture the aponeurosis between the Rectus Femoris and Vastus Intermedius muscle group is shown in Fig. 3 with a ROI in yellow in the Rectus Femoris (RF). Fig. 4-A,B show the 3D velocity and positive and negative strain rate eigenvectors in the ROI as a function of isometric contraction cycle, while Fig. 5A,B show the eigenvectors corresponding to the positive eigenvalue for isometric contraction for the same ROI at peak shortening or lengthening; other studies of strain rate maps derived from the velocity images in the calf have shown that the strain rate orientation deviates from the fiber direction. Since these deviations may be related to lateral transmission, alterations in the fiber and SR orientations may potentially help identify altered muscle function as in patients with repaired ACL.