Muscle Stiffness Differs Between Myositis Patients and Healthy Controls

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Introduction: Muscle is a complex tissue that adapts to mechanical and biochemical changes in its environment. Diseases that directly affect muscle can significantly interfere with quality of life. One such group of diseases are known as idiopathic inflammatory myopathies (IIM or myositis), and include dermatomyositis, polymyositis, and inclusion body myositis. All have in common lymphocytic infiltration of muscles, edema within the muscle, altered muscle composition, and impaired muscle function. Associated with these changes is a decrease in muscle endurance and/or strength which can be disabling, and which may persist, post treatment. Traditional assessments of disease activity include manual muscle strength testing (i.e. the clinician resists the movement of the limbs), measurements of muscle enzymes, electromyography studies, muscle biopsy, and disease activity measures as defined in the literature (Oddis et al., 2005). While these methods are useful clinical tools, questions still arise about the affects of the disease and its treatment on the muscle. More specifically, what are the effects of myositis on the muscle type and the surrounding matrix as a whole, as well as what is the cause of the continued lack of endurance, in many, despite treatment? We hypothesized that muscle extracellular matrix, reflected by stiffness, is important not only for the force transmission, thus the function of the muscle, but also the mechano-biology of the cell, thus the response to treatment. Therefore, evaluating the stiffness of muscle tissue will reveal information about the conditions of muscle extracellular matrix, which in turn may provide insight on the effects of myositis on muscle extracellular matrix. The purpose of this study is to adopt a novel technique to assess the shear modulus (stiffness) of the muscles of the proximal leg for this patient population.

Materials and Methods: Magnetic Resonance Elastography (MRE) is a novel MRI technique that can visualize propagating mechanical waves as they pass through tissue (Muthupillai, et al., 1995). From displacement images, inversion algorithms are used to provide an estimation of the shear modulus (stiffness) of a tissue. Six patients with active IIM according to elevated levels of muscle enzymes, muscle weakness, and disease activity measures, have completed the MRE scan protocol (4 women, 2 men, average age 53.8 years). Two of the female patients had polymyositis, while the third had inclusion body myositis (IBM). One female and both male patients had dermatomyositis. Six age-matched control subjects, with no history of muscle disease or dysfunction were used for comparison. Participants lay supine in a custom-made non magnetic positioning device with knees flexed at approximately 30°. Both feet were placed in footplates consisting of two MR compatible load cells that measured horizontal and vertical forces. Scans of the Vastus Medialis (VM) were taken at three contraction levels: relaxed, 10%, and 20% maximum voluntary contraction (MVC). Visual feedback regarding the amount of force generated during the scan was provided to the patient via a custom LabView Program. Shear waves were delivered to the thigh using a pneumatic driver consisting of a remote pressure driver (i.e. a large active loudspeaker) connected to a hose, which connects to a smaller silicone tube. This smaller tube was positioned 1/3 the distance between the patellar tendon to the anterior superior iliac spine. The varying pressure wave caused the tube around the thigh to expand and contract creating vibration. An operating frequency of 90Hz was used and a custom-made Helmholtz surface receiver coil was utilized for data acquisition. Manual inversion was used to estimate a quantitative value for the shear stiffness or shear modulus of the muscle. The leg more affected by myositis was scanned. If the patient did not know which was more affected or felt both were affected equally, the right leg was scanned. The dominant leg of the controls was always scanned.

Results: Calculated stiffness was compared to age-matched controls. Though the study population is small, averaged values for five of the six patients showed decreased stiffness values in the relaxed and active states as can be seen in Figure 1. The data from the sixth patient (IBM) yielded no stiffness value as the wave attenuation was too great.

Discussion: Treatment outcomes vary in IIMs. Actual assessment of muscle involvement can be problematic using standard clinical and laboratory measures such as manual muscle testing and quantification of muscle enzymes. Prior to treatment and during the disease course, overt muscle weakness may not be observed, yet patients complain of muscle fatigue and lack of endurance. We believe it possible, that these observations could be directly related to changes in the extracellular matrix as well as other proteins within the muscle that may not be detected by conventional methods. However, these same changes can in fact have an effect on the stiffness of the muscle. While considerable variation was seen in this particular sample of patients with IIM, there are definite differences observed when compared with control subjects. This study has shown MRE to be a potential tool for detecting the differences of muscle stiffness in myositis patients and controls. This information may become important to understanding muscle function from the perspective of extracellular matrix behavior, as well as the responses to treatment. MRE will allow us to explore the variability of muscle conditions providing a potential basis for understanding changes in endurance.

References: Oddis et al., Arthritis Rheum 52(9):2607-15, 2005