

MR-Elastography Reveals Skeletal Muscle Elasticity Changes in Patients with Hypogonadism Prior to Testosterone Substitution and After 6 Months

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Introduction:

The reduction of testosterone concentrations in men with hypogonadism has been shown to reduce bone density and muscle mass and lead to increased body fat concentration. Many of these patients undergo testosterone substitution therapy, whereby the patient is provided with a controlled dosage of testosterone. Over approximately six months, the patients recover to nearly normal testosterone levels. To determine the state of the patient at diagnosis, a multitude of tests, some invasive, must be performed. MRE is a noninvasive, novel approach for monitoring patient response to testosterone therapy by measuring muscle stiffness under various loads [1]. In this study, the effect of testosterone substitution was evaluated by MRE by measuring patients with hypogonadism prior to testosterone substitution and after 6 months of treatment.

Methods and Materials

Subjects: Men over 18 years of age who were diagnosed with unequivocal hypogonadism (n=12), defined as a serum testosterone concentration less than 300 mg/dL (10.4 nmol/L) were recruited for the study. Thus far, six of these patients have had a six month follow-up MRE examination.

MRI Experiment: All MRI experiments were performed on a 1.5T whole-body system (Magnetom Sonata, Siemens AG, Erlangen). The subjects lay supine on the MR table with their feet securely fastened to a home-built foot plate. The foot plate, used for measuring applied force via a strain gauge, was fixed at a 90° angle. Localization scans were initially performed followed by 5 MRE scans. For MRE, a modified gradient echo sequence (TR/TE 120/33.3 ms, flip angle 15°, matrix 180/80) was employed. During the individual MRE scans, the subjects were required to maintain a force on the foot plate of 0%, 5%, 10%, 15%, and 20% of their maximum voluntary contraction (MVC). All force measurements were recorded on a PC and were later reviewed to determine if the target force was maintained during the MRE scans.

MR Elastography: MRE was performed by mechanically exciting the muscle tissue with a custom designed piezoelectric actuator [2]. For the mechanical excitation of the muscle tissue, the actuator lever was placed on the anterior surface of the calf approximately 5 cm below the knee. An excitation frequency of 100 Hz was used for imaging the soleus muscle. A total of 8 phase offsets were acquired.

Data Analysis: All phase images were phase unwrapped and reconstructed into shear modulus elastograms using the local frequency estimation (LFE) technique [3]. The resultant elastograms were then averaged over all 8 phase offsets, and regions-of-interest were used to calculate the shear modulus of the soleus muscle. The shear modulus data in the soleus were plotted as a function of %MVC. A two-way repeated-measures ANOVA (SPSS ® Version 12.0) was used to determine statistical differences in the shear moduli for various MVC between the two groups (pre and post treatment).

Results:

The shear modulus data of the soleus muscle at 0%, 5%, 10%, 15% and 20% of the MVC prior to treatment and after 6 months are presented in Figure 1. There were statistical differences seen between the two time points at 0%, 5%, 10% and 20%. There was also a statistical difference between testosterone levels prior to and after 6 months of treatment (6.12 nmol/l ± 0.89 nmol/l [SE] → 22.81 nmol/l ± 10.67 nmol/l [SE]).

Discussion:

The present study clearly demonstrates the effect of testosterone substitution on muscle stiffness. After treatment with testosterone over 6 months, the soleus muscle is stiffer when under load. Thus MRE seems to be a promising technique for non-invasive evaluation of therapy effects in patients with hypogonadism. Larger studies have to be done to confirm our initial experiences.

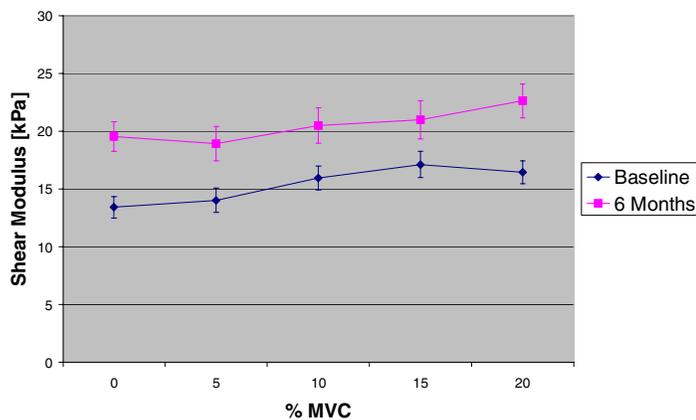


Figure 1: Shear modulus [kPa] versus %MVC in patients with hypogonadism prior to testosterone substitution and after 6 months of treatment. .

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- [3] Manduca A, et al., Image processing for MRE (Magnetic resonance imaging). SPIE, 1996; Vol. 2710:616-623