Magnetic Resonance Elastography (MRE) for Measurement of Muscle Stiffness of the Shoulder: Feasibility with a 3T MR Imaging System

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Pulpose:

To determine the feasibility of the MRE using 3T MR in measuring of the stiffness of the shoulder muscles.

Methods:

Institutional review board was approved and informed consent was obtained. Prospective evaluation of 16 healthy volunteers (mean age, 29.8 years, ranges: 25 to 51 years) without myofascial pain was performed. MRE was acquired with 3T MR by using a 2D-gradient-echo–based MRE sequence at two different excitation frequencies of 90 and 120 Hz. The mean stiffness values of the trapezius and infraspinatus muscles were measured by two radiologists. Difference between the mean stiffness values in the x, y, and z motion-sensitization directions and interobserver agreements were assessed.

Results:

The mean stiffness values of the trapezius muscle at 90 Hz and 120 Hz were 2.72 kPa ± 0.6 (SD) and 4.66 kPa ± 1.2, respectively, those for the infraspinatus muscle were 3.2 kPa ± 0.52 and 4.38 kPa ± 0.92, respectively. The mean stiffness values for both muscles at 120 Hz were significantly higher than those at 90 Hz ($p < 0.05$). The mean stiffness values in the three different directions were significantly different from each other in the infraspinatus muscle ($p < 0.05$). There was good to excellent inter-observer agreement in the mean stiffness measurements of trapezius (ICC = 0.979-0.996) and infraspinatus muscles (ICC = 0.614-0.943).

Conclusion:

MRE is feasible at 3T in evaluation of the muscle stiffness of the shoulder muscles. Extended application of the skeletal muscle MRE in different magnetic fields will enrich its application to variety of skeletal muscle disorders.

Table 1. Mean Stiffness Values Calculated from Different Directions of Sensitization of the Trapezius and Infraspinatus Muscles at 90 Hz and 120 Hz Excitation Frequencies.

	90 Hz				120 Hz				120Hz – 90Hz
Frequency	Mean stiffness and standard deviation (kPa)								
MSD	x	y	z	mean	x	y	z	mean	P values
Trapezius	2.65 ± 0.74	2.74 ± 0.60	2.77 ± 0.61	2.72 ± 0.6	5.13 ± 1.97	4.70 ± 1.11	4.16 ± 0.95	4.66 ± 1.2	$p < 0.05$
Infraspinatus	3.63 ± 0.87	3.19 ± 0.77	2.59 ± 0.65	3.2 ± 0.52	6.07 ± 2.07	3.89 ± 0.88	3.18 ± 0.86	4.38 ± 0.92	$p < 0.05$

Note- MSD: motion-sensitization directions

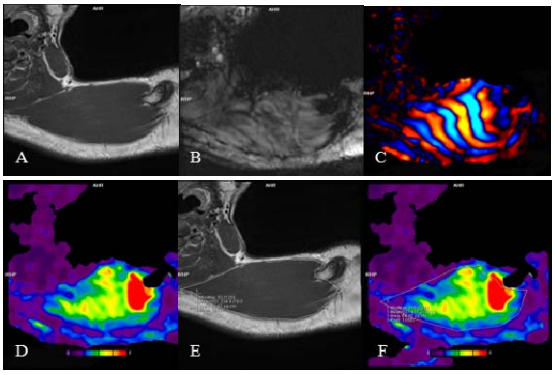

Figure 1. A 32-year-old man. Proton density oblique axial images through the trapezius (**A**) were used to choose the location for the MRE acquisition at an excitation frequency of 90 Hz (**B-D**). From the gradient echo MRE acquisition magnitude images (**B**) eight sets of post-processed images are displayed; the wrapped phase shift wave image (**C**); the stiffness color map (**D**). The stiffness measurements were made on the images (**D**), and the color scale reflects the stiffness in Pascals. ROIs were drawn over the trapezius perimeter on the proton density images (**E**) and then copied and pasted on the matching stiffness color map (**F**). In this volunteer, the measured mean stiffness of the trapezius muscle was 2.73 kPa, and longitudinal wave pattern is seen as in radiate muscle (**C**).