Editorial Commentary: Single−Image Slice Magnetic Resonance Imaging Assessments Do Not Predict 3-Dimensional Muscle Volume

Abstract: No single-image magnetic resonance imaging (MRI) assessment—Goutallier classification, Fuchs classification, or cross-sectional area—is predictive of whole-muscle volume or fatty atrophy of the supraspinatus or infraspinatus. Rather, 3-dimensional MRI measurement of whole-muscle volume and fat-free muscle volume is required and is associated with shoulder strength, which is clinically relevant. Three-dimensional MRI may represent a new gold standard for assessment of the rotator cuff musculature using imaging and may help to predict the feasibility of repair of a rotator cuff tear as well as the postoperative outcome. Unfortunately, 3-dimensional MRI assessment of muscle volume is labor intensive and is not widely available for clinical use.

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As practitioners of a fickle discipline subject to the vagaries of human nature and Murphy's law (whatever can go wrong, will go wrong and at the worst possible time), we crave certainty. Single-slice evaluation of magnetic resonance imaging (MRI) scans for fatty atrophy in the supraspinatus and infraspinatus, such as the Goutallier or Fuchs classification (Table 1)[1,2] or measurement of the cross-sectional area (CSA) of the muscle (used in the investigation by Vidt et al.,[3]) as evaluated by the method described by Zanetti et al.,[4] once offered a hope of predicting the repairability and outcome from rotator cuff surgery. Despite the clinical appeal of viewing a single image as a predictor of rotator cuff tear characteristics, the reliability of the Goutallier classification has not been high.[5-8] The investigation authored by Vidt et al.,[3] "Assessments of Fatty Infiltration and Muscle Atrophy From a Single Magnetic Resonance Image Slice Are Not Predictive of 3-Dimensional Measurements" showed that single-image MRI did not capture 3-dimensional measures of fatty infiltration or muscle volume. Three-dimensional assessments of muscle morphology indicate that muscle atrophy, not increased fatty infiltration volume, determines increased fat percentages in patients with rotator cuff tears. Furthermore, muscle volume measurements are significant predictors of strength in older patients with and without rotator cuff tears, highlighting the need for clinicians to consider the amount of muscle tissue because strength capacities are known to have functional limitations. Previous work has indicated that muscle volume is a significant predictor of upper limb strength.[9-11]

Vidt et al.[3] used 3 observers for the Goutallier and Fuchs assessments and measurements at 2 different times; the mean CSA for 2 observers was reported. Not surprisingly, the interobserver and intrarater reliability for the Goutallier, Fuchs, and CSA classifications was poor, with a few exceptions noted in Table 3 of their article.

The rotator cuff tear group had smaller-whole muscle volumes for the supraspinatus, infraspinatus, and subscapularis. There were significant associations between whole-muscle volume and fat-free muscle volume and strength.

Unfortunately, as the authors noted, they had a small sample size, particularly when further dividing into the 5 Goutallier grades. Three-dimensional MRI assessment of muscle volume is a research tool that, at present, is not available for clinical imaging because of its labor-intensive nature. It may be the gold standard for future research in the area of muscle assessment by conventional imaging.

None of the single-image MRI assessments—Goutallier classification, Fuchs classification, or CSA—was significantly associated with whole-muscle volume for the supraspinatus and infraspinatus. Adding credence to the authors' method of 3-dimensional MRI measurement of whole-muscle volume and fat-free muscle volume was the positive association with strength. The work of Vidt et al.[3] has extinguished the

Table 1. Comparison of Goutallier Grade to Fuchs Stage

Muscle Status	Goutallier Grade	Fuchs Stage
Normal muscle	0	0
Some fatty streaks	1	0
< 50% fatty muscle atrophy	2	1
50% fatty muscle atrophy	3	2
> 50% fatty muscle atrophy	4	2

NOTE. Muscle Status refers to the muscle appearance on a single computed tomography image immediately lateral to the scapular spine's attachment to the body of the scapula for the Goutallier classification[1]; according to the classification of Fuchs et al.,[2] Vidt et al.[3] applied the system to magnetic resonance imaging with a T1-weighted scan for the image slice with the hopes of improving reliability.

hope of single-image MRI fatty assessment, as currently evaluated, as a predictor of rotator cuff repairability and outcome from surgical treatment. For those of you who hope to attach your name to MRI muscle assessment as a predictor of rotator cuff tear repair results, there is still opportunity.

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