

## **Role of ultrasound in the evaluation of rotator cuff muscle quality: A review**

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### **Abstract**

The evaluation of the quality of rotator cuff muscles has become an important part of the preoperative ultrasound examination. Ultrasound is accurate in the evaluation of rotator cuff integrity, but has been found to be insufficient compared to magnetic resonant imaging (MRI) in the evaluation of rotator cuff muscle quality. Complete tears of the rotator cuff lead to muscle atrophy and fatty infiltration, these changes are known to be important negative prognostic factors with regard to the anatomical and functional results after tendon repair. Several classifications and grading systems have been described for computed tomography (CT) and MRI. A number of studies have been directed at the ultrasound assessment of muscle atrophy and fatty infiltration of the rotator cuff, however, no quantitative method or grading systems have been established. At present MRI is the preferred choice for evaluation of rotator cuff fatty infiltration and muscle atrophy in clinical practice. Ultrasound is widely available, cost effective and safe; the aim of this literature review is to investigate if there is a role for ultrasound in the examination of rotator cuff muscle quality.

**Keywords:** Ultrasound, rotator cuff, muscle atrophy, supraspinatus, fatty infiltration.

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### **Introduction**

Complete tears of the rotator cuff tendons lead to muscle atrophy and fatty infiltration. These changes are known to be important negative prognostic factors with regard to the anatomical and functional results after tendon repair (Ostlere, 2003). The assessment of muscle quality is therefore a crucial element in evaluating surgical indications and post-operative prognosis (Khoury, Cardinal & Brassard, 2008).

Normally, the supraspinatus muscle bulk occupies the supraspinatus fossa deep to the trapezius. The normal muscle has a pennate echopattern, which consists of hypoechoic muscle bundles, separated by thin hyperechoic lines - the fibroadipose septa or perimysium (Figure 1a) (Ptasznik & Franzer, 2001). Two different muscle abnormalities, namely atrophy and fatty infiltration, are observed when the rotator cuff tendons are torn. With atrophy, there is decreased muscle bulk. With fatty infiltration, the muscle becomes hyperechoic due to a

decrease in hypoechoic muscle bundles and an increase in hyperechoic fibro adipose septa and fat, with a loss of the pennate appearance. Although these changes are closely interdependent, they are not perfectly correlated; but both atrophy and fatty infiltration increase with time after tendon rupture (Figure 1b) (McNally, 2005).

A number of studies have been directed at the ultrasound assessment of muscle atrophy and fatty infiltration of the rotator cuff, however, no quantitative method or grading systems have been established. At present MRI is the preferred choice for evaluation of rotator cuff fatty infiltration and muscle atrophy in clinical practice. The aim of this review is to investigate if there is a role for ultrasound in the examination of rotator cuff muscle quality.

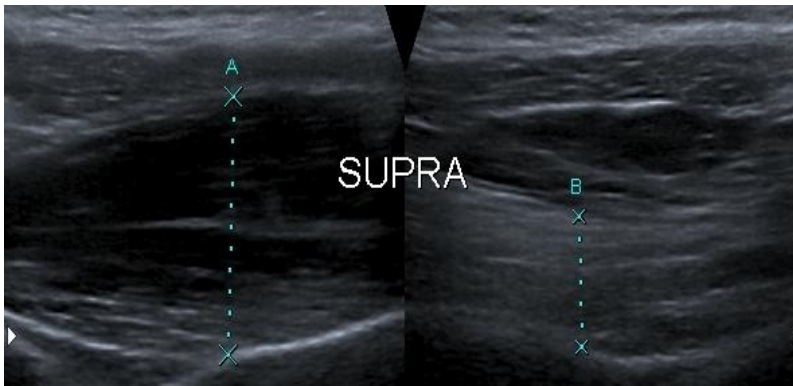


Fig. 1a: Normal Muscle      1b: Atrophy and fatty infiltration

(Coronal plane of supraspinatus muscle)

### **CT classification of fatty infiltration**

A classification of fatty infiltration was established by Goutallier et al. (1994), based on computed tomography (CT). Five stages were described:

- Stage 0 - normal muscle;
- Stage 1 - some fatty streaks;
- Stage 2 – more muscle than fat;
- Stage 3 – amount of fat equal to muscle; and
- Stage 4 - more fat than muscle

## **MRI grading of muscle atrophy**

Thomazeau et al. (1996) graded muscle atrophy on MRI by calculating the occupation ratio of the supraspinatus fossa, which is the ratio between the cross-section of the muscle belly and that of the fossa on the Y view (oblique sagittal plane that crosses the scapula through the medial border of the coracoid process). Three grades were identified:

- Grade I- Ratio between 1.00 and 0.6. Muscle is considered normal or slightly atrophied.
- Grade II- Ratio between 0.60 and 0.40. Muscle moderately atrophied.
- Grade III- Ratio below 0.40. Muscle severely atrophied (Thomazeau et al., 1996)

## **Ultrasound evaluation of rotator cuff muscle quality**

Ultrasound has been shown to be useful in the evaluation of rotator cuff muscle quality and a number of studies have been directed at the assessment of muscle atrophy and fatty infiltration (Sofka, Haddad & Adler, 2004; McNally, 2005). There is, however, no quantitative method or grading system for the evaluation of muscle atrophy and fatty infiltration with ultrasound.

Sofka et al. (2004) used increased echogenicity and decreased muscle bulk as indicators of muscle atrophy. Unfortunately, their study lacked standard reference, while the degree of muscle atrophy (mild, moderate or severe) was also not quantified (Sofka et al., 2004; Khoury et al., 2008).

Strobel, Hodler, Meyer, Pfirrmann, Pirkl & Zanetti (2005) reported that ultrasound is only moderately accurate in grading fatty infiltration. A limitation of their study was the use of static images and the comparison with the deltoid. They used four parameters: visibility of outer contour, central tendon, pennate pattern, and echogenicity to assess both atrophy and fatty infiltration simultaneously, whereas quantification of the degree of muscle atrophy (muscle size) was not performed. The echogenicity was graded in comparison to that of the deltoid (Strobel et al., 2005; Khoury et al., 2008). Ashry, Schweitzer, Cunningham, Cohen, Babb & Cantos (2007) found that the fatty infiltration that increases in normal muscles with age, occur more frequently in the deltoid, excluding the potential of this muscle as a standard of reference (Ashry et al., 2007)

## **Evaluation of rotator cuff muscle quality on ultrasound compared to MRI**

Khoury et al. (2008) compared ultrasound with MRI for the evaluation of supraspinatus muscle atrophy and fatty infiltration. Fatty infiltration was graded on MRI according to the method described by Goutallier et al. (1994), mentioned

earlier. On ultrasound, fatty infiltration was assessed by evaluating its echogenicity and pennate pattern. The echogenicity of supraspinatus was compared with trapezius to determine if it was isoechoic, mildly hyperechoic or markedly hyperechoic. The pennate pattern was described as normal - homogeneously distributed, well-defined hyperechoic streaks; effaced - slight loss of pennate pattern with blurring of the margins of hyperechoic streaks; or absent-loss of pennate pattern with poor or no visibility of the streaks Khoury et al., (2008). The study showed that in most cases, echogenicity and pennate pattern correlated with the degree of fatty infiltration on MRI and that ultrasound has an advantage over MRI in that it is able to assess the internal architecture of muscle and its pennate pattern. By grading echogenicity as mild or marked, and the pennate pattern as either effaced or lost, they could not distinguish moderate from severe fatty infiltration using ultrasound, because marked hyperechogenicity and lost pennate pattern correlated with both moderate and severe fatty infiltration on MRI. The distinction between moderate and severe infiltration may not be as important clinically as distinguishing mild from moderate or severe infiltration, because many studies state that the likelihood of a recurrent tear is the same when fatty infiltration is greater than mild or Goutallier Stage 2.

Khoury et al. (2008) suggested the following ultrasound grading scale for the evaluation of supraspinatus muscle fatty infiltration. In the absence of fatty infiltration (Goutallier, Stage 0), echogenicity is normal and the pennate pattern preserved. With mild fatty infiltration (Goutallier, Stages 1 and 2), there is mild hyperechogenicity and an effaced pennate pattern. With moderate to severe fatty infiltration (Goutallier, Stages 3 and 4), there is marked hyperechogenicity and absent pennate pattern (Khoury et al., 2008).

Several methods have been proposed to evaluate muscle bulk on MRI, although the method of Thomazeau et al. (1996) is probably the most widely used. Because the Y view uses osseous landmarks, it can be easily reproduced with ultrasound. They first showed on MRI that it is as accurate to use the ellipse (modified Thomazeau method) as it is to draw lines as originally described by Thomazeau et al. (1996). The study showed that there is an excellent correlation between the occupation ratios measured on MRI and on ultrasound using the modified Thomazeau method. The authors concluded that the Thomazeau classification of supraspinatus muscle atrophy can be transposed to ultrasound as follows:

- an occupation rate of  $>0,60$  is Stage I (normal to mild atrophy);
- $0,40-0,60$  Stage II (moderate atrophy); and
- $<0,40$  is Stage III (severe atrophy).

Their study showed good correlation between ultrasound and MRI for the assessment of both supraspinatus muscle atrophy and fatty infiltration (Thomazeau et al., 1996).

## **Conclusion**

Ultrasound is accurate in the evaluation of rotator cuff integrity, but has been found to be insufficient compared to MRI for preoperative evaluation of rotator cuff muscle quality. Khoury et al. (2008) found that there is a good correlation between ultrasound and MRI in the assessment of both supraspinatus muscle atrophy and fatty infiltration. They established the following grading system for fatty infiltration and atrophy:

Fatty Infiltration in relation to Goutallier Classification (Khoury et al., 2008):

- Gr 0: Normal echogenicity and pennate pattern
- Gr 1 – 2: Mild hyperechogenicity and an effaced pennate pattern
- Gr 3 – 4: Moderate to severe; marked hyperechogenicity and absent pennate pattern

Muscle Atrophy according to Thomazeau Classification (Khoury et al., 2008):

- Stage I: normal to mild atrophy  $> 0.60$
- Stage II: moderate atrophy  $0.40 - 0.60$
- Stage III: severe atrophy  $< 0.40$

The aim of this literature review was to investigate the role of ultrasound in the evaluation of rotator cuff muscle quality. At present MRI is the preferred imaging modality in clinical practice but limitations are high cost and the unavailability in sub-Saharan Africa. Khoury et al. (2008) established an ultrasound classification for fatty infiltration and muscle atrophy and concluded that ultrasound may be used as an accurate evaluation of supraspinatus atrophy and fatty infiltration.

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