J Shoulder Elbow Surg (2015) 24, 288-294

ELSEVIER

Journal of Shoulder and Elbow Surgery

www.elsevier.com/locate/ymse

Fluoroscopic, magnetic resonance imaging, and electrophysiologic assessment of shoulders with massive tears of the rotator cuff

Karl Wieser, MD[a,*], Stefan Rahm, MD[a], Martin Schubert, MD[b], Michael A. Fischer, MD[c], Mazda Farshad, MD, MPH[a], Christian Gerber, MD, FRCS[a], Dominik C. Meyer, MD[a]

[a]*Department of Orthopaedics, Balgrist University Hospital, University of Zürich, Zürich, Switzerland*
[b]*Department of Neurology, Balgrist University Hospital, University of Zürich, Zürich, Switzerland*
[c]*Department of Radiology, Balgrist University Hospital, University of Zürich, Zürich, Switzerland*

Background: It was the purpose of this paper to analyze structural, functional, and electrophysiologic variables that may determine preserved overhead function for patients with massive rotator cuff tears.
Methods: Nineteen patients (20 shoulders) were prospectively included in either the pseudoparalytic ($n = 9$) or the non-pseudoparalytic group ($n = 11$). Fatty infiltration was graded according to Goutallier, and anterior (subscapularis) and posterior (infraspinatus and teres minor) tear extension was graded 0 (no involvement) to 4 (full tear) on magnetic resonance imaging. Glenohumeral and scapulothoracic rhythm was assessed by fluoroscopic motion analysis, and electromyographic evaluation of the deltoid muscle was performed.
Results: We found no significant difference of fatty infiltration of the supraspinatus (3.9 vs 3.6), infraspinatus (3.9 vs 3.8), and teres minor (1.7 vs 0.6) or of the posterior tear extension (2.6 vs 2.0) between pseudoparalytic and non-pseudoparalytic shoulders. Global tear extension in the parasagittal plane (205° vs 163°) and subscapularis involvement (2.6 vs 1.2), however, showed significant differences between the two groups, and no patient with a full-thickness supraspinatus and infraspinatus tear with extension into the inferior half of the subscapularis was able to lift the arm to 90°. Fluoroscopic assessment revealed almost total loss of active glenohumeral abduction in the pseudoparalytic group.
Conclusion: Despite global tear extension, the single most important predictor for preserved shoulder function is the integrity of the inferior subscapularis insertion. Furthermore, electromyographic evaluation identifies a well-differentiated deltoid innervation as beneficial for a well-preserved shoulder function, but it does not protect from pseudoparalysis.
Level of evidence: Basic Science, Kinesiology.

Keywords: Massive rotator cuff tear; pseudoparalysis; EMG; myotendinous retraction; fatty infiltration

The study was performed at the Balgrist University Hospital, University of Zürich, Zürich, Switzerland.
The study was approved by the Cantonal Ethics Committee of Canton Zurich (KEK-Zürich) (IRB No. 2011-0243).
Dr Wieser and Dr Rahm contributed equally to this investigation (share first authorship).

*Reprint requests: Karl Wieser, MD, Department of Orthopaedics, Balgrist University Hospital, University of Zürich Forchstrasse 340, CH-8008 Zürich, Switzerland.
E-mail address: karl.wieser@balgrist.ch (K. Wieser).

1058-2746/$ - see front matter © 2015 Journal of Shoulder and Elbow Surgery Board of Trustees.
http://dx.doi.org/10.1016/j.jse.2014.05.026

Rotator cuff (RC) tears are common pathologic processes, and large tears can lead to a severe impairment of shoulder function. Between 10% and 40% of all cuff tears are classified as massive[8,9,13]; most authors consider tears massive if at least 2 complete tendons are torn.[11]

Massive rotator cuff tear (MRCT) is commonly associated with loss of strength and active mobility. The disability caused by loss of strength, however, differs widely from a hardly detected weakness to pseudoparalysis, which describes the painless inability to abduct the arm to 90° with a normal passive range of shoulder motion in the absence of neurologic impairment.[21]

Despite its unquestioned clinical relevance, it is still not known which patient with MRCT will develop pseudoparalysis and which one will not. Furthermore, patients suffering RC tear patterns without obvious differences diagnosed on magnetic resonance imaging (MRI) present clinically with completely different shoulder impairments as exemplified by the patient depicted in Figure 1. Therefore, we hypothesized that the deltoid muscle might play a major role in determining remaining shoulder function. It seems appropriate to assume that for a full and strong global shoulder function, not only a normally innervated but also an optimally coordinated deltoid action is indispensable.

In a previous study investigating the morphology of the deltoid muscle, we found that the shape of the deltoid was influenced by natural aging but did not correlate with the shoulder function in patients suffering from RC tears of different sizes.[17] However, a failure in muscle fiber recruitment or poor neurophysiologic muscle coordination may lead to an imbalance of the deltoid areas with a possible decentralization of the humeral head and consequently impaired shoulder function.

We therefore conducted this study to systematically analyze anatomic, functional, and electrophysiologic variables that may determine overhead function for patients with MRCT to test our hypotheses that pseudoparalysis will be determined by the RC tear size and pattern with an imbalanced anterior to posterior muscle force, development of anterosuperior glenohumeral escape, and possibly disturbed neurophysiologic coordination.

Methods

Between November 2011 and December 2012, 19 consecutive patients (20 shoulders) with unrepaired and passively fully mobile MRCTs, defined as involvement of at least 2 complete tendons,[11] were prospectively included in either the pseudoparalytic (PP) shoulder group ($n = 9$) or the non-pseudoparalytic (NP) group ($n = 11$). Furthermore, a control group of 6 patients with unimpaired shoulder joints (age-adapted Constant score[5,22] of 100%) was recruited to set the baseline for the new measurement techniques. All patients gave informed consent, had a shoulder MRI study within 3 months of the examination date, and underwent a standardized clinical shoulder examination including a Constant-Murley score and dynamic fluoroscopic motion analysis. Patients with pain level above 3 on the visual analog scale (range, 0-10) were injected subacromially with local anesthetics (15 mL lidocaine 1%) approximately 20 minutes before the fluoroscopic motion analysis ($n = 3$). This relieved pain to a level of less than 3 of a maximum of 10 on a visual analog scale.

Electrophysiology

Electromyographic studies were performed by an experienced neurologist (M.S.). To exclude a relevant axillary nerve lesion, needle electromyography of all 3 portions of the deltoid muscle was performed. Patients from the control group and 3 patients under oral anticoagulation from the NP group did not undergo needle electromyography. To analyze deltoid coordination, surface electrodes were placed on the anterior, middle, and posterior portions of the deltoid muscle. The patient was in a sitting position, letting the arm hang to the side, and was asked to perform shoulder flexion, shoulder abduction, and shoulder extension. Each movement was repeated 3 times, and the latencies of the 3 portions of the deltoid muscle (in seconds) and the amplitude of each portion (in microvolts) were measured.

MRI

MRI was performed on a 1.5T MRI unit (Symphony; Siemens, Munich, Germany). The shoulder was placed in a dedicated receive-only shoulder coil with the arm in neutral position and the thumb pointing vertically. MRI protocols included T1-weighted spin-echo images in the coronal oblique plane with fat saturation (792/20; section thickness, 3 mm; field of view, 160/160 mm; matrix size, 265/512), in the transverse plane (500/30; section thickness, 3 mm; field of view, 160/160 mm; matrix size, 256/512), and in the sagittal oblique plane (500/30; section thickness, 4 mm; field of view, 160/160 mm; matrix size, 256/512). T2-weighted fast spin-echo images (3000/20; section thickness, 4 mm; field of view, 160/160 mm; matrix size, 256/512) and intermediate-weighted fast spin-echo images (2350/20; section thickness, 4 mm; field of view, 160/160 mm; matrix size, 256 3 512) were obtained in the coronal oblique plane with fat saturation. The MRI data were stored on a picture archiving and communication system workstation, and the provider's image analysis software was used for review and measurement of images.

All MRI studies were analyzed by consensus read-out of one experienced radiologist with 2 years of special training in musculoskeletal radiology and two orthopedic surgeons with 5 to 6 years of training in orthopedic and particularly shoulder surgery.

The selective retraction and shortening of the supraspinatus (SSP) tendon and muscle were assessed according to Meyer et al.[16] On a T2-weighted oblique coronal section through the center of the SSP tendon, the tear size (distance from the lateral edge of the humeral articular surface to the tendon end) and the deep (articular) myotendinous junction (muscle retraction) were measured. The distance between the measured tendon end and the myotendinous junction was defined as the SSP tendon stump.

To establish the relation of the remaining anterior force of the subscapularis (SSC) vs the combined posterior forces of the infraspinatus (ISP) and teres minor (TM),[1] we graded, on a T2-weighted parasagittal plane through the center of the humeral head, the anterior and posterior tear extension in 25% steps from