Magnetic resonance imaging of the shoulder: rationale and current applications

R. Gary Holt, M.D., Clyde A. Helms, M.D., Lynne Steinbach, M.D., Christian Neumann, M.D., Peter L. Munk, M.D. *, and Harry K. Genant, M.D.

Department of Radiology, University of California, San Francisco, California, USA

Abstract. Because it can demonstrate a wide range of tissue contrast with excellent resolution, magnetic resonance (MR) imaging has revolutionized imaging in many areas of the musculoskeletal system and has generated excitement among those interested in the painful shoulder. Shoulder impingement syndrome and glenohumeral instability constitute the two major categories of shoulder derangements. Correct diagnosis requires the use of appropriate pulse sequences and imaging planes, proper patient positioning, and a satisfactory surface coil. In addition, the imager must have a thorough understanding of shoulder anatomy and pathology. We present a summary of the current status of MR imaging of the shoulder including technical, anatomic, and pathologic considerations and a review of the pertinent literature.

Key words: Magnetic resonance imaging (MRI) – Shoulder, imaging – Shoulder, instability – Shoulder impingement syndrome – Glenoid labrum – Rotator cuff disease

Magnetic resonance (MR) techniques have revolutionized imaging in many areas of the musculoskeletal system, most notably in the knee [6, 20, 28]. This success has generated great excitement among those interested in the painful shoulder which, after headache and backache, is the third most common general medical complaint [2].

Why, then, has MR imaging of the shoulder failed to gain the same rapid acceptance among imagers and clinicians as MR of the knee? As in the knee, successful MR imaging of the shoulder requires a magnet system capable of producing images with high resolution, good signal to noise ratio, and reasonably quick scan times. In addition, appropriate pulse sequences are critical in the display of both normal and abnormal anatomy.

Additional problems, however, must be solved to properly image the shoulder. Unlike the knee, the shoulder cannot be positioned within a highly efficient volume coil. It is located relatively far from the magnet isocenter and is adjacent to the thorax which contains a number of potential artifact-producing structures. Furthermore, the relevant anatomy of the shoulder is oriented obliquely to the standard orthogonal imaging planes. These technical problems have been overcome only recently by new hardware and software developments permitting satisfactory MR imaging of the shoulder.

In addition to these technical requirements, a thorough knowledge of shoulder anatomy as well as some understanding of shoulder disease is necessary. Further confounding the shoulder diagnostician is a lack of consensus as to the etiology or the progression of rotator cuff disease, the most common shoulder problem [4, 24]. Further, there is a great deal of controversy over surgical intervention, including arthroscopy, in early rotator cuff disease [1, 10].

In this review, we will summarize current MR imaging techniques, present a rationale for imaging based on normal and abnormal anatomy, and offer our opinion on the current clinical status and possible future uses of shoulder MR imaging.

Summary of current techniques

The patient is positioned supine with the arms along the sides and the arm to be imaged externally rotated. The technician must insure that the arm imaged is not placed on the abdomen, otherwise respiratory motion will be transmitted to the shoulder. An angled pair of
counter-rotating current-loop-gap resonators (Medical Advances, Milwaukee, WI) 7.5 cm in diameter is positioned so that the center of the anterior coil is approximately 1 cm above the skin anterior to the lesser tuberosity of the humerus (Fig. 1). These coils allow more uniform signal reception and improved signal to noise ratio than planar coils; their technical features have been previously described [14, 15]. The patient is then advanced into the bore of the magnet. The images in this report were obtained with a superconducting magnet operating at 1.5 T (Signa, GE, Milwaukee, WI). With software recently available from the manufacturer (3.2/Performance Plus), off axis centering and oblique imaging planes can be prescribed, allowing the use of small fields of view and comfortable patient positioning.

MR imaging of the shoulder requires the use of imaging planes geometrically appropriate to the anatomy to be depicted [31]. A number of pulse sequences with T1, proton density, T2, or T2*-weighting are available; however, total imaging time will be a limiting factor in most clinical situations. Our current shoulder imaging protocol is given in Table 1.

An axial SE sequence (TR 800/TE20) is useful for evaluating the glenoid labrum and the capsular structures. Recently we have begun to use a gradient-echo sequence (TR 300/TE10/flip angle 90 degrees) which seems to offer superior depiction of the labrum, tendons, and capsular structures. From one of these sequences the technician selects the plane of section for the oblique coronal series. The cursor is aligned so that the plane of section is parallel to the course of the supraspinatus muscle and tendon (Figs. 2 and 3). A TR of 800 is used to insure adequate coverage of the structures in question. A TE of 20 is optimal for anatomic depiction and high signal to noise ratio. This sequence is repeated using gradient echo TR 400/TE20/flip angle 30 degrees. These sequences are crucial for demonstrating the supraspinatus tendon, subacromial-subdeltoid bursa, the undersurface of the acromion and the acromioclavicular joint, and the superior and inferior labrum. In addition the multiplanar gradient echo sequence clarifies the nature of abnormal signal in the suspect tendons and bursa, permitting the detection of fluid and the identification

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Table 1. Summary of shoulder MRI protocols at the University of California, San Francisco

Fig. 1. Proper positioning of the patient and the paired surface coils for imaging the left shoulder

Fig. 2. Axial T1-weighted image through the supraspinatus muscle and tendon (arrows) annotated with the locations of the oblique coronal images. L = lateral; P = posterior

Fig. 3. T1-weighted oblique coronal image demonstrating a normal supraspinatus muscle and tendon (arrows). Note the homogeneous low signal intensity of the tendon and its broad base of attachment on the greater tuberosity of the humerus. gt = greater tuberosity; ssm = supraspinatus muscle; L = lateral