SCIENTIFIC PAPERS

Magnetic resonance imaging of the shoulder in patients with rheumatoid arthritis

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Abstract

To evaluate the ability of magnetic resonance imaging (MRI) to detect shoulder abnormalities 18 patients (36 shoulders) with rheumatoid arthritis (RA) and shoulder complaints were studied. Osseous abnormalities of the glenoid and humeral head were readily detected with MRI. The imaging planes used were not suitable for the evaluation of acromioclavicular joint involvement. Magnetic resonance imaging depicted soft tissue abnormalities that were not clearly visualised by plain film radiography, such as involvement of rotator cuff tendons and subacromial bursae, joint effusion, and muscular atrophy. Magnetic resonance imaging appears to be a sensitive method for evaluation of glenohumeral joint changes in patients with RA.

The shoulder is one of the more common sites of involvement of rheumatoid arthritis (RA). Rheumatoid arthritis not only affects the synovium within the glenohumeral joint but can also involve the distal third of the clavicle, bursae, rotator cuff tendons, and surrounding muscles.^{1 2}

Clinically, shoulder arthritis can often go unrecognised. There are several reasons for this: the onset of the disease in the shoulder is often insidious, the shoulder joint is deeply seated, and synovial tissue swelling often escapes notice as it is difficult to detect unless suspected. It is important to recognise shoulder involvement early and if possible, to prevent further damage by conservative treatment—for example, by careful physiotherapy with active and passive movements, before irreversible changes have occurred.

Radiography can be helpful in determining the extent of shoulder involvement in RA. Radiographic assessment of the stage of the disease is based on the presence of bone erosions, joint space narrowing, and osteoporosis. Joint erosions, not specifically the shoulder, usually occur within the first two years of the disease.³ Joint space loss and osteoporosis are not specific for RA.^{3 4}

Magnetic resonance imaging (MRI) has proved its usefulness in the evaluation of the musculoskeletal system.^{5 6} Owing to its superior soft tissue contrast, tomographic nature, and multiplanar imaging, MRI is particularly valuable for assessment of the synovium, cartilage, muscles, tendons, and ligaments.^{7 8}

This study was undertaken to determine whether MRI can provide more information about shoulder involvement in patients with RA

than physical examination combined with plain radiographs.

Patients and methods**PATIENTS**

Eighteen consecutive patients with definite or classical RA, according to the American Rheumatism Association criteria,⁹ who had visited the outpatient clinic of the department of rheumatology and had shoulder complaints were included in the study. All patients gave their informed consent to participation in the study. The table gives the clinical details of these patients. This group included seven female and 11 male patients with median age 63 years (range 42–79) and median duration of disease five years (range 1–23); one patient was seronegative and 17 were seropositive. According to x rays of the wrists, hands, and forefeet five patients had non-erosive and 13 had erosive disease. Fifteen of the 18 patients had been or were being treated with disease modifying drugs. The motion of 30 shoulders was restricted for anteflexion or abduction or both (table).

METHODS

Plain radiographs were taken in the anteroposterior (arm in exorotation) and axial views. The radiographs were evaluated in concert by two of the authors (BACD, HMK), one radiologist, and one rheumatologist without knowledge of the results of the MRI studies. Involvement of the glenohumeral joint, major tuberosity, and acromioclavicular joint was graded by the scoring method described by Kellgren¹⁰: grade 0 no abnormalities, grade 1 dubious erosions, grade 2 definite but mild erosions, grade 3 more destructive changes, and grade 4 severe erosions.

Magnetic resonance imaging studies of the shoulders were performed with a 0.5 tesla superconductive magnet MRI system (Gyrosan S5 Philips, Best, The Netherlands). A flexible 'wrap around' surface coil was used. Multiple images in the transverse and oblique planes—that is, perpendicular to the glenoid surface, were obtained. The oblique plane has been described in detail.⁸ Spin echo pulse sequences with relative T1 weighting (600, 30) (repetition time ms, echo time ms) and relative T2 weighting by the dual echo technique (2000, 50–100) were used in all examinations. To keep the scanning time within acceptable limits two excitations were used in all cases. The total scanning time for both shoulders was less than one hour. A 250 mm field of view and 5 mm

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Clinical, radiographic and magnetic resonance imaging (MRI) findings in 18 patients with rheumatoid arthritis

Patient number	1	2	3	4	5	6	7	8	9	10	11
Sex	F	M	M	M	M	M	F	M	M	M	F
Age (years)	77	63	75	53	79	57	47	76	42	47	58
Duration of RA (years)	1	19	12	2	1	12	13	1	2	5	5
Seropositive/negative	+	+	-	+	+	+	-	+	+	+	+
Erosive/non-erosive	E	E	NE	E	NE	E	E	NE	E	E	E
Anteflexion (degrees)*	170 170	160 170	160 170	90 110	180 160	170 170	180 180	180 180	170 170	170 160	170 170
Abduction (degrees)*	90 90	90 90	80 90	70 40	90 80	80 80	90 90	90 90	80 80	90 90	70 70
Glenohumeral involvement*											
Radiography	0 0	0 0	0 0	3 3	0 0	0 0	0 0	0 0	2 0	0 2	2 1
MRI	0 2	0 2	0 0	4 2	0 0	2 0	0 0	1 2	2 2	0 2	2 2
Acromioclavicular joint involvement †											
Radiography	1 2	0 0	0 0	2 3	0 0	1 0	0 0	0 0	0 0	0 0	0 2
MRI	2 0	2 0	0 0	1 0	3 0	0 0	0 0	3 3	1 0	0 0	0 0
Minor and major tubercle involvement ‡											
Radiography	0 0	1 0	1 0	4 4	0 0	1 1	2 0	2 2	1 1	0 2	2 3
MRI	3 2	2 0	2 0	4 4	2 2	2 2	2 2	1 2	3 2	2 2	3 3
Cartilage destruction*											
Radiography	- -	- -	- -	+	- -	- -	- -	- -	- -	+	-
MRI	- -	- -	- -	+	- -	- -	- -	- -	+	- -	-
Soft tissue abnormality detected with MRI§											
Rotator cuff tendon destruction	- -	- -	- -	+	+	+	+	-	-	-	+
Rotator cuff muscle atrophy	+	+	-	+	+	+	+	+	+	-	+
Effusion or pannus	+	+	-	+	+	+	+	+	+	+	+
Lymph nodes	+	+	-	+	+	+	+	+	+	+	+

*Values given for right shoulder:left shoulder.

†Grade 0=no abnormalities; grade 1=dubious erosions; grade 2=definite but mild erosions; grade 3=more destructive changes; grade 4=severe erosions.

‡Owing to osteosynthetic material this area could not be evaluated in this patient.

§- =absent; + =present; ++ =severe.

thick contiguous sections were chosen in combination with a 154×256 acquisition matrix and a 512×512 display matrix.

Figure 1 shows the magnetic resonance images of the shoulder of a normal volunteer. Patient positioning proved simple. A comfortable neutral humeral position with the patient supine was chosen. The images were interpreted by two of the authors (GJK, JLB), both radiologists, in concert without knowledge of the clinical history or radiographic findings. The findings for 110 subjects without RA, who had undergone MRI of the shoulders for a variety of other reasons, as well as the findings for 10 normal volunteers and two cadaveric shoulders served as controls.⁸⁻¹¹ Magnetic resonance images were evaluated by the scoring system used for the radiographs. Bone erosions were defined as marginal osseous defects with a low or non-homogeneous signal intensity on T1 weighted images.¹²⁻¹³ Joint effusion was diagnosed when the joint capsule was distended by material that was identified by its low signal intensity on T1 weighted images and high signal intensity on T2 weighted images.¹⁴ Normal

synovial fluid is not visible on magnetic resonance images; when it is abnormal (pannus formation) it has a low signal intensity on T1 and low or high signal intensity on T2 weighted images.¹⁰⁻¹⁵ Normal hyaline articular cartilage has an intermediate signal intensity on T1 and T2 weighted images. Cartilage disease was diagnosed when the articular cartilage had thinned focally or diffusely.

In a final session the radiographs and magnetic resonance images were reviewed together by two of the authors (GJK, BACD) to establish whether or not the magnetic resonance images provided additional information.

Results

Magnetic resonance images of adequate technical quality were obtained in all cases. A metallic artefact was present in one shoulder, and thus the region of the tuberosities and the lateral part of the rotator cuff tendons in this shoulder could not be evaluated. Other artefacts were minimal; if present they were attributable to motion.

Figure 1: Magnetic resonance images of a normal left shoulder (37 year old healthy man). (a) T1 weighted (repetition time (TR) 600 ms, echo time (TE) 30 ms) image of the supraspinatus tendon and muscle taken in the oblique plane; (b) T2 weighted (TR 2000, TE 100) image in the same plane; the relative intensities of the normal musculoskeletal tissues remain the same; note the normal subdeltoid bursa (arrows); (c) T1 weighted (TR 600, TE 30) transverse image at the level of the coracoid process. 1=humeral head; 2=acromion; 3=glenoid cavity; 4=coracoid process; 5=supraspinatus muscle; 6=supraspinatus tendon; 7=infraspinatus muscle; 8=subscapular muscle; 9=deltoid muscle; 10=trapezius muscle; 11=acromioclavicular joint; 12=tendon of the long head of biceps muscle.

12	13	14	15	16	17	18
F	M	F	F	M	F	M
73	52	69	66	66	73	55
23	12	2	13	4	1	9
+	+	+	+	+	+	+
E	E	NE	E	E	NE	E
160/160	170/170	160/150	160/180	45/50	50/150	90/90
90/90	70/70	80/80	80/90	45/30	20/80	70/90
0/0	4/2	0/0	0/0	3/2	3/0	1/1
0/0	4/2	0/0	4/0	4/3	2/2	0/2
0/0	0/0	2/2	1/2	1/1	2/0	0/0
0/0	0/0	2/0	2/0	4/0	2/2	0/1
2/2	3/‡	1/1	2/2	4/3	3/2	2/0
2/2	4/‡	0/2	2/2	4/3	2/2	2/2
-/-	+/+	-/-	-/-	+/+	+/-	-/-
-/-	+/-	-/-	-/-	+/+	+/-	+/-
-/++	+/‡	+/+	-/-	++/++	+/+	+/+
++/++	+/-	+/+	++/++	++/++	++/+	+/+
+/+	-/-	+/+	+/-	++/++	++/-	++/++
+/-	-/+	-/-	-/-	-/-	-/+	+/-

The table lists the osseous abnormalities detected with plain film radiography and MRI. All erosions visualised by plain film radiography, both at the tuberosities and in the glenohumeral joint, were easily seen on the magnetic resonance images. Glenohumeral joint involvement of grade 2 or more was shown in 10 shoulders by plain film radiography and in 19 shoulders by MRI. Abnormalities of grade 3 or more at the tuberosities were detected in 18 shoulders with radiography and in 31 shoulders with MRI. There were no significant abnormalities on the plain film radiographs that were not observed with MRI. Figure 2 shows an example of these osseous abnormalities.

In five cases MRI was unable to detect erosive changes in the acromioclavicular joint that were clearly visible on the plain radiographs. On the other hand, MRI showed abnormalities in six shoulders which were not seen with plain film radiography.

Joint space narrowing at the glenohumeral joint was diagnosed in eight joints by plain film radiography. The magnetic resonance images indicated that cartilage destruction had probably occurred in seven of these eight joints and in three additional joints. The hyaline articular cartilage showed no signal intensity changes with disease.

The soft tissue abnormalities detected by MRI included rotator cuff tendon involvement in 11 and complete tendon destruction in five shoulders (table). Mild atrophic changes in the rotator cuff muscles were detected in five shoulders; in nine other cases the cuff muscles were severely atrophied. Figures 3 and 4 show examples of soft tissue abnormalities.

Magnetic resonance images showed joint effusion or inflammatory synovial tissue in the glenohumeral joint or the subacromial bursa, or both, in 22 joints.

Signal intensity of inflammatory synovial tissue in or adjacent to osseous erosions varied on T2 weighted images: eight times it produced a low signal, 15 times a high signal, and three times a mixed signal intensity (fig 4). Enlarged axillary lymph nodes (>1 cm) were detected in 14 shoulders.

No systemic correlation between limitation of joint motion and radiological findings could be

Figure 2: Small erosions and joint effusion in the right shoulder of patient No 9. (a and b) Anteroposterior and axial radiographs show a small erosion at the greater tuberosity; (c) oblique T1 weighted (repetition time (TR) 600 ms, echo time (TE) 30 ms) magnetic resonance image also shows the erosion (arrows) and in addition, an intact supraspinatus muscle; (d) transverse T1 weighted magnetic resonance image (TR 600, TE 30) visualises two erosions in the humeral head (arrows); (e) transverse T2 weighted image (TR 2000, TE 100). A joint effusion appears as an area of high signal intensity in both the joint space and the sheath of the biceps tendon (arrows).

Figure 3: Destructive changes in the right shoulder of patient No 4. (a) Anteroposterior radiograph shows severe erosions and elevation of the humeral head; (b) transverse T1 weighted (repetition time (TR) 600 ms, echo time (TE) 30 ms) image shows complete destruction of the humeral head by the inflammatory process (arrows); infraspinatus and subcapsular muscles are severely atrophic (curved arrows); (c) oblique T1 weighted (TR 600, TE 30) image shows degeneration of the supraspinatus muscle (black arrows), absence of its tendon, and a subdeltoid bursa filled with pannus (white arrows).

Figure 4: Changes in the signal intensity of inflammatory tissue within osseous erosions and hypertrophied synovium on T1 and T2 weighted images of the right shoulder of patient No 16. (a) T1 weighted (repetition time (TR) 600 ms, echo time (TE) 30 ms) image shows pannus in the glenohumeral joint and the subacromial bursa as well as the erosion which appear as areas of low signal intensity (arrows). Note also severe atrophy of the supraspinatus muscle. (b) T2 weighted (TR 2000, TE 100) image: pannus in the joint and the erosion are now seen as areas of high signal intensity (arrows).

found. In general, the radiographs and MRI of severely impaired shoulders showed more severe abnormalities—for example, patients Nos 4 and 16; shoulders with little or no impairment proved to be severely involved radiologically—for example, patients Nos 11, 12, and 13.

Discussion

The main conclusion of our study is that MRI of the shoulder can provide information about osseous and soft tissue involvement of the

glenohumeral joint in patients with RA; moreover, MRI gives more information than plain film radiography. It has to be noted, however, that the results of two radiological procedures were compared without having a gold standard.

Soft tissue swelling was easily detected with MRI. A joint effusion has a low signal intensity on T1 and a high signal intensity on T2 weighted images. Osteoporosis itself cannot be visualised with MRI, but the processes that lead to osteoporosis—synovial inflammation and pannus formation—can be detected. Pannus formation appeared as areas of low signal

intensity on T1 weighted images and as areas of low or high signal intensity on T2 weighted images. This variation in signal intensity on T2 weighted images can be related to the difference between acute and chronic inflammation¹³ or to haemosiderin deposits within the hypertrophied synovium.^{12 16} There are similarities between pannus and fluid on T2 weighted images. When both fluid and pannus had a high signal intensity on T2 weighted images we found it possible to differentiate these two tissues with extreme T2 weighting. In such cases the fluid has a higher signal than the synovial tissue.

In our series bone erosions could be better shown with MRI than with plain radiography, presumably owing to the tomographic nature and multiplanar ability of MRI. Hyaline articular cartilage can be visualised directly with MRI and diffuse destruction as well as focal damage can be depicted. In one case, however, MRI did not show cartilage abnormalities, whereas the plain films showed an obvious loss of joint space. This fault was probably due to a thin layer of fluid within the joint space. In addition, MRI provided information about the integrity of the rotator cuff tendons.

Atrophic changes in the rotator cuff muscles could also be detected. Involvement of the acromioclavicular joint was not visualised in several cases. Because our image plane is perpendicular to the glenoid it passes through the acromioclavicular joint at an angle, resulting in suboptimal visualisation of the joint.⁸ For this reason other planes should be chosen for evaluation of the acromioclavicular joint.

As a result of this study we have become aware that damage to the tissues of the shoulder joint is already present even when the radiographs are still quite normal. The correlation between clinical findings and tissue damage as detected by MRI and radiography is quite poor. Other conditions, such as osteoarthritis and chondrocalcinosis, may produce cysts or defects in trabecular bone similar to those in RA. Future investigations will be necessary to see if we are able to differentiate between these disease processes.

In conclusion, MRI is able to assess soft tissue and bone involvement of the glenohumeral joint in RA that is difficult to evaluate by other means. Other joints of the appendicular skeleton can also be evaluated; moreover, MRI is non-invasive and painless and there are no biological risks involved. In view of its reproducibility MRI could become an objective method for observing the stages of the disease and eventually for monitoring response to treatment.

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