The Value of Magnetic Resonance Imaging in Clinical Practice

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The use of magnetic resonance imaging (MRI) has expanded significantly over the last several years with regard to the diagnosis and management of musculoskeletal diseases. The availability of in-office MRI has allowed many rheumatologists to consider it for improved convenience, accessibility, and comfort for patients with musculoskeletal limitations. Office MRI is a "low-field" technique, so it is important to consider this in comparison to conventional "high-field" MRI.

LOW-FIELD VERSUS HIGH-FIELD MRI

The advances of low-field MRI ranging from 0.2 to 1.5 T in strength, which from a musculoskeletal perspective can image both coaxial and peripheral joints, have superseded the previously utilized and somewhat limited extremity MRI, which as the name suggested was capable of imaging only a limited number of peripheral joints. The accessibility, versatility, and user-friendliness of low- field MRI has become the MRI technology of choice for clinical practitioners specializing in musculoskeletal disorders, in particular, rheumatologists and orthopedic surgeons. Readers should be aware that there are different models available, each with its own particular pros and cons. This article is not meant to cover the individual technological differences, and it is recommended that individual due diligence is performed when evaluating the different choices available.

It is important to recognize that most of the published literature does not always specifically state whether low-field or high-field MRI was used. Therefore, the value of MRI findings, in a particular instance, should be interpreted as to how the MRI scans may help the practicing rheumatologist. It is also important to realize that MRI in clinical practice may provide different information than images in a research environment.

Regarding low-field MRI versus conventional MRI, there are several advantages and disadvantages to be considered T1 (Table). Low-field MRI does not require a radiofrequency-shielded room, the positioning is more comfortable for patients, it is easy to prepare, and because it can be done in the office, it is much more convenient for patients and; therefore, less time is wasted. The disadvantages of low-field MRI are that is has a lower spatial resolution, a smaller field of view, the imaging time is longer, and it provides a reduced number of possible imaging techniques.[1] Low-field MRI is not as useful for evaluation of cartilage. It also important to note that the ranges of low-field MRI from the 1.5-T MRI and 0.2-T MRI are diagnostically equivalent. A study by Taouli et al[2] compared high-field MRI, low-field MRI, and conventional radiograph when looking at rheumatoid arthritis (RA) in the hand/wrist. Using the Sharp-Genant scoring system (erosions, synovitis, joint space narrowing), they found that low-field MRI was lower in cost, and patients were more compliant with its use. They also showed that low-field, dedicated extremity MRI provided similar information on bone erosions and synovitis as that of the more expensive high-field MRI units.[2]

Utilizing a standard low-field unit, one is able to assess the elbow, hand, wrist, knee, ankle, and foot. With a larger low-field unit, the shoulder and hip can be looked at, and with an even larger magnet, physicians can assess cervical and lumbar spine and sacroiliac joints. The higher up to 1.5-T (still low-field) field strengths produce a higher resolution of images and faster examination times. They also provide for a better depiction of articular cartilage defects and a more accurate assessment of labral tears, partial- and small full-thickness tendon tears, and fat saturation.

MRI INDICATIONS

Support for various indications has been obtained largely from studies with high-field MRI, although as noted above low-field MRI should be largely comparable.

RHEUMATOID ARTHRITIS

Most of the published data on MRI in rheumatology are for RA. Since the advent of biological therapy in the late 1990s, many treatment algorithms have utilized MRI either for early diagnosis to capture the so-called window of opportunity, to differentiate inflammatory arthritis from other conditions, and ultimately determine the benefit of chosen treatment.

In 2013, *Annals of Rheumatic Diseases* published The European League Against Rheumatism Recommendations for the Use of Imaging in the Joints in the Management of Rheumatoid Arthritis.[4] The task force identified 6888 references, from which 199 studies were included in the systematic review. Ten recommendations were developed based on research-based evidence and expert opinion. These recommendations provide a practical rationale for the clinician when determining whether imaging modalities should be used in clinical practice. Potential uses include helping make a diagnosis of RA, detecting inflammation and damage, predicting outcomes and response to treatment, and monitoring disease activity, progression and remission. Of the 10 recommendations, which included different imaging modalities such as conventional radiography, ultrasound, MRI, and computed tomography, among others, MRI was the only modality suggested for consideration for all 10 recommendations.

The 2011 American College of Rheumatology/European League Against Rheumatism definition of remission in RA for clinical practice states that at any time point the patient must satisfy all of the following requirements: Swollen Joint Count, Tender Joint Count, Patient Global Assessment all greater than 1 and a CDAI greater than 2.8.[5] While many believe that remission predicts the best clinical, functional, and structural outcomes, there is an apparent dissociation between clinical remission and continued structural deterioration. Magnetic AQ2

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TABLE. Low Field Versus Conventional MRI

Advantages	Disadvantages
No radiofrequency-shielded room required	Lower spatial resolution
Positioning more comfortable	Smaller field of view
Easy site preparation	Longer imaging time
In-office convenience, less time wasted	Reduced number of possible imaging techniques
Low-field imaging depending on strength can image all peripheral joints, including shoulder, elbow, wrist, hand, hip, knee ankle, and foot, as well as cervical and lumbar spine	Low-field MRI is less sensitive to imaging cartilage, thoracic spine, and sacroiliac joints. It is not designed to be utilized for the chest, brain, spinal cord, and abdomen

resonance imaging can detect subclinical joint inflammation in RA patients in clinical remission who are receiving conventional therapy. Several studies have demonstrated that MRI provides a greater sensitivity than clinical examination and traditional radiography when assessing disease activity, and subclinical inflammation can be identified by MRI in the majority of patients in either clinical remission or low disease activity state.[6]

In RA, bone edema is the strongest predictor of erosive progression.[7] Erosion risk is 6.5 times higher with preceding edema.[8] The CIMESTRA study, probably the largest data set (130 patients), found that MRI bone edema was the strongest predictor of radiographic progression after 2 years.[9] Research also suggests that the baseline MRI osteitis score is more predictive of MRI erosions at 6 years than other MRI features, AQ3 DAS, or C-reactive protein alone and that the baseline MRI osteitis score is more predictive of disability based on SF-36 than other MRI features.[10]

Jimenez-Boj et al[11] looked at resected joints from 3 patients with advanced RA undergoing joint replacement. The researchers aligned slices of preoperative MRI scans with histological sections of the excised bone and found that bone F1 edema corresponded with regions of inflammation (Figure).

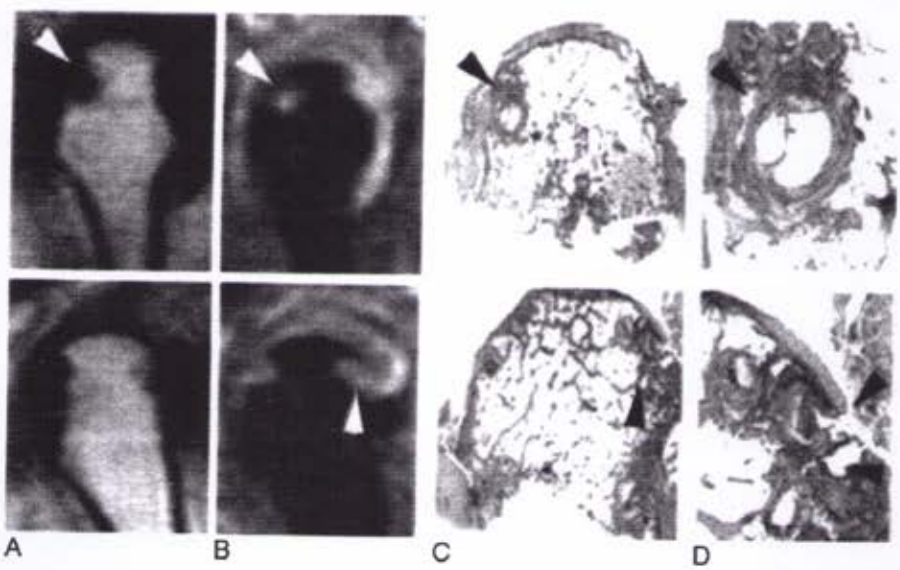
For the practicing Rheumatologist, these findings are potentially important especially if future studies demonstrate the utility of MRI to guide altered therapy in clinical practice and improve the health care outcomes for patients. As an example, one suggestion has been that detection of synovitis might lead one to choose a tumor necrosis factor inhibitor, whereas osteitis may determine the use of a B-cell modulator.[12]

In conclusion, several studies have demonstrated the value of and importance of earlier, aggressive treatment of RA. This indicates a need for more sensitive indicators in order to assess pre-erosive features. Magnetic resonance imaging could be an important component of the evaluation for disease progression and therapeutic response, therefore leading to improved patient quality of life and optimal health care outcomes.[13]

OSTEOARTHRITIS

Based on the results of a Delphi exercise, The Osteoarthritis Research Society International has published the following consensus statements regarding MRI and osteoarthritis (OA).[14]

- MRI changes of OA may occur in the absence of radiographic findings of OA.
- MRI may add to the diagnosis of OA and should be incorporated into the American College of Rheumatology diagnostic criteria, which were originally developed in 1986 before MRI being considered standard of care.[15]
- MRI may be used for inclusion in clinical studies but should not be a primary diagnostic tool in a clinical setting.
- Certain MRI changes in isolation including cartilage loss, cartilage compositional change, cystic change and bone marrow lesions, ligamentous and tendinous damage, meniscal damage, and effusion and synovitis are not diagnostic of OA.



AQ4 FIGURE.

In knee OA, bone marrow lesions on MRI are strongly associated with pain, and bone marrow edema is a strong risk factor for deterioration.[16]

Furthermore, the utilization of MRI may be critical in separating OA from isolated meniscal or cartilage damage. These conditions may be separate or coexist and very difficult clinically to differentiate. Currently, utilization of MRI for OA in a clinical setting can have benefits but should not be considered a mandatory study in clinical situations where the diagnosis and treatment may be without doubt.

ANKYLOSING SPONDYLITIS

The New York criteria for the diagnosis of ankylosing spondylitis (AS) included a radiographic procedure looking at the anteroposterior view of the pelvis.[17] Findings of sacroiliac involvement on MRI may now be very suggestive of a diagnosis of AS and have been incorporated in the criteria for the diagnosis of AS.[18] A 2010 study of 315 patients with primary back pain concluded that degenerative sacroiliac joint disease may be an underrecognized clinical entity. There is at times a long delay between the onset of symptoms and time to diagnosis of AS. Magnetic resonance imaging has added to the improved diagnosis of AS. While the sensitivity and specificity of MRI-defined lesions have not been identified in an unselected back pain cohort, and in some cases MRI is limited by cost and/or availability, MRI may prove to be an extremely valuable tool.[19]

PSORIATIC ARTHRITIS

Over the last few years, we have seen that MRI can help with the identification of enthesitis, tendonitis, and dactylitis, all of which are features that can aid in the diagnosis of psoriatic arthritis (PsA). In addition, these advances in imaging techniques enable clinicians to assess the efficacy of therapies for the treatment of PsA. One study of 30 patients using whole-body MRI at 1.5 T with contrast agent examined a range of pathologies including synovitis and enthesitis. The whole-body MRI detected more synovitis and enthesitis than clinical examination, which suggests that there may be implications for diagnosis and the concept of subclinical disease.[20]

The Group for Research and Assessment of Psoriasis and Psoriatic Arthritis believes that MRI has potential for increased use in PsA with regard to diagnosis, monitoring, prediction of disease course, and treatment response based on the studies that have been conducted.[21]

UTILIZATION OF CONTRAST

Based on literature reports and clinical experience, most practicing physicians do not use contrast with low-field MRI. This is, in part, due to the increased time involved and the increased risk of nephrotoxicity. Magnetic resonance imaging shows significant benefit in determining bone edema with or without contrast. In addition, with regard to the use of contrast, this may only be a perceived benefit. Although synovitis may be highlighted, it may result in a false-positive. In summary, the high-field MRI with contrast is the criterion standard when assessing RA disease activity. This may not always be feasible, and field strength, use of contrast, and number of joints imaged need to be customized based on clinical practice requirements.[22]

While gadolinium-enhanced MRI provides a highly sensitive assessment of inflammation and joint damage in RA, intravenous gadolinium injection prolongs examination time and increases the cost, invasiveness, and patient comfort. A 2009 study by Ostergaard et al[23] assessed changes in inflammatory and destructive joint changes by OMERACT RAMRIS when omitting intravenous contrast injection. The researchers found that omitting intravenous contrast injection did not change the scores of bone edema and bone erosions; however, there was 1 disadvantage in that it did decrease the reliability of synovitis scores. It is important to consider that the possibility to assess more joints and/or greater feasibility may outweigh the disadvantage.[23] Many other studies have demonstrated that the use of contrast influences synovitis scores, and higher synovitis scores correlate with double doses of gadolinium compared with single-dose evaluation. There are; however, concerns of nephrogenic systemic fibrosis in patients with severely diminished renal function. Because of this, high-dose gadolinium is viewed with more caution than previously. The standard dose of 0.1 mmol/kg is the standard recommendation.[24,25]

IMPLEMENTING MRI INTO CLINICAL PRACTICE

It is imperative to review all specifications and the costs associated with MRI when deciding to implement the system into one's office. Office space is an important consideration regarding patient and staff flow. It is also extremely important to review one's monthly referral volume, that is, the body part to be examined, and to verify that the referral volume supports the decision to implement the use of MRI in the office. A financial proforma should be created regarding financial choices and the option of leasing versus purchasing. Other factors that should be considered include a contract with the vendor, installation time, contracting with a radiologist who will interpret the readings, and adequate training and support for all staff members. It is also important that physicians and staff have an adequate understanding of the diagnosis codes [3] along with the billing and coding for MRI [4]. The insurance companies will generally reimburse a separate fee for the technical component and the diagnostic reading interpretation, the latter of which is almost exclusively performed by a radiologist who ideally has had additional specialized training in musculoskeletal disorders. AQ5

CONCLUSIONS

As discussed, MRI can be an important tool for the practicing rheumatologist with regard to both diagnosis and management of various musculoskeletal diseases. It has been shown that low-field MRI is efficient and convenient for both physicians and patients. The quality of images is comparable to larger magnetic fields and more than sufficient for most musculoskeletal disorders. The capabilities of choosing the reader who ideally should be a board-certified musculoskeletal-trained radiologist, fast turnaround times, and a business model, which when implemented correctly, all enhance the capabilities and offerings of the modern rheumatology outpatient facility.

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