Musculoskeletal MRI Structured Evaluation

How to Efficiently Fill the Reporting Checklist

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Wolters Kluwer

2nd EDITION

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Second Edition

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Technical Considerations

Avneesh Chhabra and Theodoros Soldatos

MR imaging is the method of choice for the detection of internal derangements of the various soft tissue structures of joints. Meticulous attention and correct application of various pulse sequences and MR techniques are essential for achieving optimal quality imaging. The latter is essential for superior depiction of the bony and soft tissue structures of the joints and related para-articular regions. Ideally, the examinations should be directed based on clinical information from the referring clinicians and as prescribed by the protocoling radiologist, with active involvement of the performing technologist, as well as engagement of the patient and interpreting radiologist, all participating as a team to obtain the best imaging quality. This chapter presents the MR imaging techniques and available pulse sequences and highlights their advantages and limitations, along with a guide on how to build different musculoskeletal MRI protocols.

HUMAN CONSIDERATIONS

Referring Physician

Close interaction between the referring clinician and the radiologist is important for protocol prescription and correct interpretation of imaging findings. Clinicians should be informed or aware of the technical limitations of MR imaging (e.g., the larger the anatomy to be covered, the longer the overall examination may take, and the resolution may be degraded). The protocols vary depending upon whether the clinical question is injury, pain, or other nonspecific symptoms (ortho protocol), infection or inflammation (infection protocol), tumor (mass protocol), labrum, full-thickness rotator cuff tear or loose body (MR arthrogram), slow-flow or high-flow vascular malformation (vascular malformation protocol), cartilage evaluation (cartilage protocol), myositis or myopathy (myositis protocol), metal-prosthesis related complications (metal artifact reduction protocol), arthritis (e.g., MR rheumatology lumbosacral for sacroiliitis), peripheral nerve evaluation (MR neurography), and finally, whole-body MRI for genetic abnormalities predisposing to malignancy, neurocutaneous syndromes, and multiple myeloma. The use of gadolinium-based contrast agents is needed for MR arthrograms, as well as in cases of suspected infection, inflammation, vascular malformation, whole-body MRI, and mass lesion.

Image manipulation (postprocessing) becomes important whenever high-end imaging is performed (e.g., with 3D imaging, functional cartilage imaging, and neurography). Although such high-end imaging may or may not be useful for the radiologist's routine interpretation, the reconstructed longitudinal images, color maps, curved and maximum intensity projections (MIPs), and heat maps serve as useful preoperative guides for the surgeons and for teaching purposes. In addition, buy-in of the subspecialist clinicians is also important when one performs such imaging on their patients since high-resolution or 3D imaging demands more imaging time, produces relatively grainy images, and lots of thin slices that have the potential to increase the evaluation time. On the other hand, 3D imaging increases the diagnostic confidence of the radiologist since smaller labroligamentous structures and thinner cartilage can be easily evaluated on a series of small sections and in any desired oblique plane along the real axis of the structure leading to tissue-specific imaging. Finally, angular or rotational measurements can be obtained on thicker slab MIPs generated from such scans like cross-sectional CT examination (Fig. 2.1).

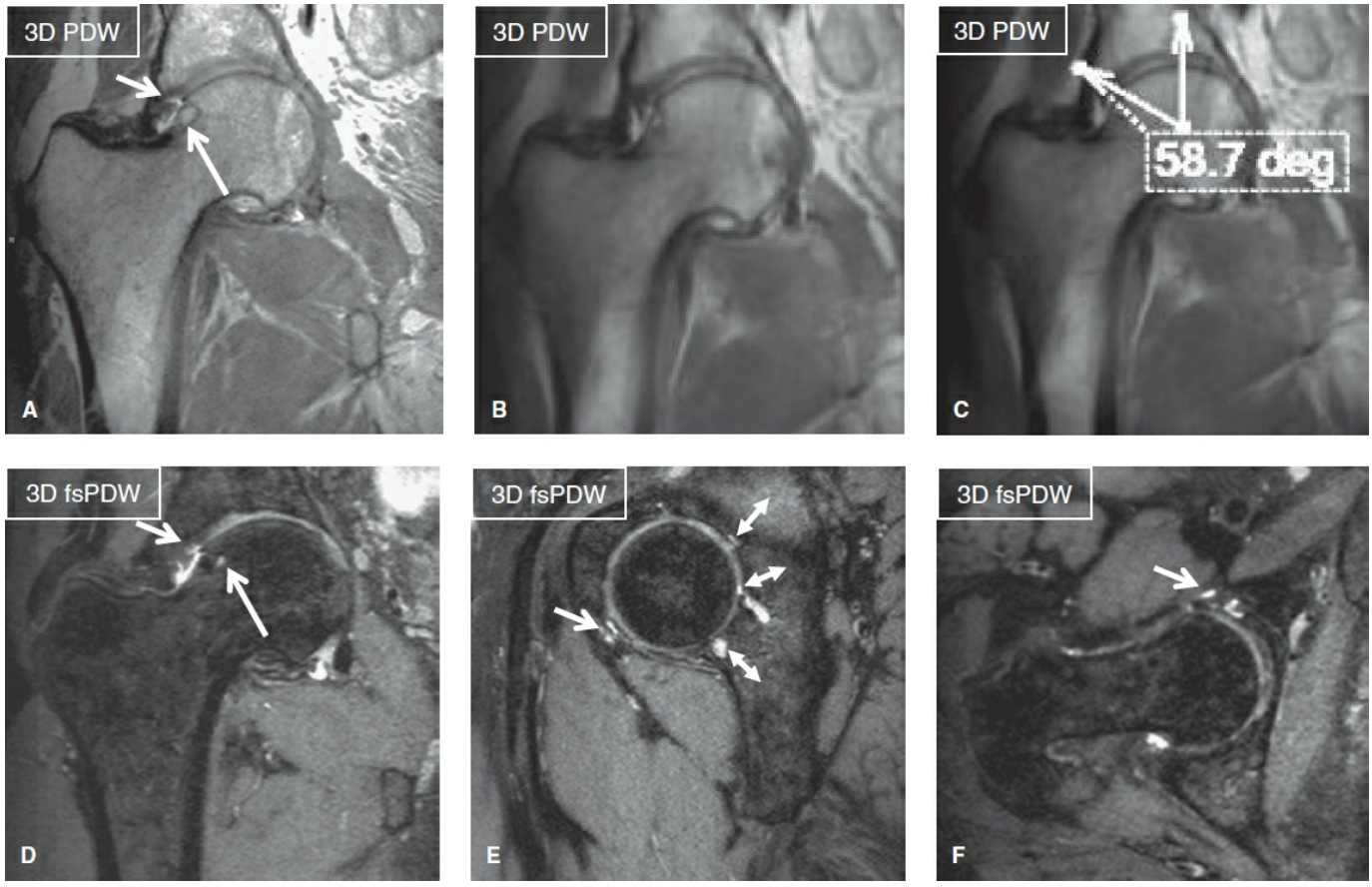

Fig. 2.1: Three-dimensional hip imaging in femoroacetabular impingement. Coronal non–fat-suppressed 3D (**A**), thick slab (**B**, **C**), and multiplanar reconstructions from fat-suppressed 3D; (**D–F**) show fibrocystic change of the right femoral head and neck junction (*long arrows*), chondrolabral separations (*short arrows*), and lateral center angle measurement in thick slab MIP (**C**). Notice elegant depiction of multiple cartilage fissures of the posterior acetabulum (*double head arrows* in **E**) in otherwise coarser-looking image due to 0.65-mm isotropic resolution.

Patient Coaching

Technologists play an important role in patient coaching for successful performance of the examination. The patient may fill out a form with most relevant acute or chronic complaints and history of prior regional surgery. Ideally, a marker should be placed at the most symptomatic painful, injured, or palpable site. The patient should be made comfortable and asked to remain still during the image acquisition. The extremity should be well padded for comfort and the coil tightly wrapped around it to restrict motion during the examination. Air and contour coils are available from different vendors, which can be snuggly wrapped like a blanket around the extremity, neck, or torso as needed. If there is motion during the study, the technologist should stop the scan, talk to the patient to make them comfortable, instruct them to stay still, and repeat the degraded sequence. One could give intravenous glucagon to decrease bowel peristalsis-related artifacts during lumbosacral plexus imaging; however, it is important to remember the contraindications (such as glaucoma) and instruct the patient of potential side effects, such as rebound hypoglycemia.

TECHNICAL CONSIDERATIONS

Scanner Selection

Since most musculoskeletal soft tissue structures are relatively small and demand high resolution, imaging is best performed on 3T scanners to make use of the higher signal-to-noise ratio (SNR). The 3T MRI-generated SNR can be traded as a currency for imaging speed, resolution, or both. Higher SNR translates into higher soft tissue contrast and faster imaging while keeping the slice thickness to a minimum, thereby enhancing the spatial (in-plane) resolution. One should aim at the smallest in-plane resolution balancing the time of acquisitions, whether imaging is performed on 1.5T or 3T. Signal averages can be used to further improve the SNR but longer scans risk motion blurring. Reducing signal averages (repeat acquisitions aka number of excitations [NEX] or number of signal averages [NSA]) and prudent use of parallel imaging can achieve faster scanning. In larger joints or larger subjects, it might be necessary to use larger voxels to maintain adequate SNR. One could use enhanced (fast) gradient mode to further improve SNR and reduce blurring effects. Imaging on 3T scanners is advantageous in obtaining 3D imaging with spin echo-type contrast, and this leads to fine evaluation of various small structures, such as menisci, cartilage, ligaments, and nerves in various arbitrary planes with isotropic resolution (Figs. 2.2 and 2.3). Three-dimensional imaging is also relatively devoid of pulsation artifacts and produces better fluid contrast, especially using DRIVE (driven equilibrium) pulse. The latter pulse not only shortens TR and makes acquisition shorter, but also increases fluid–cartilage interface conspicuity. Recent advances with sparse k-space sampling like fast parallel imaging or compressed sense have resulted in reduction of 3D MRI scan times of most joints to within 3 to 4 minutes using higher acceleration factors. Artificial intelligence approaches can further clean up the images to increase spatial and contrast resolutions.

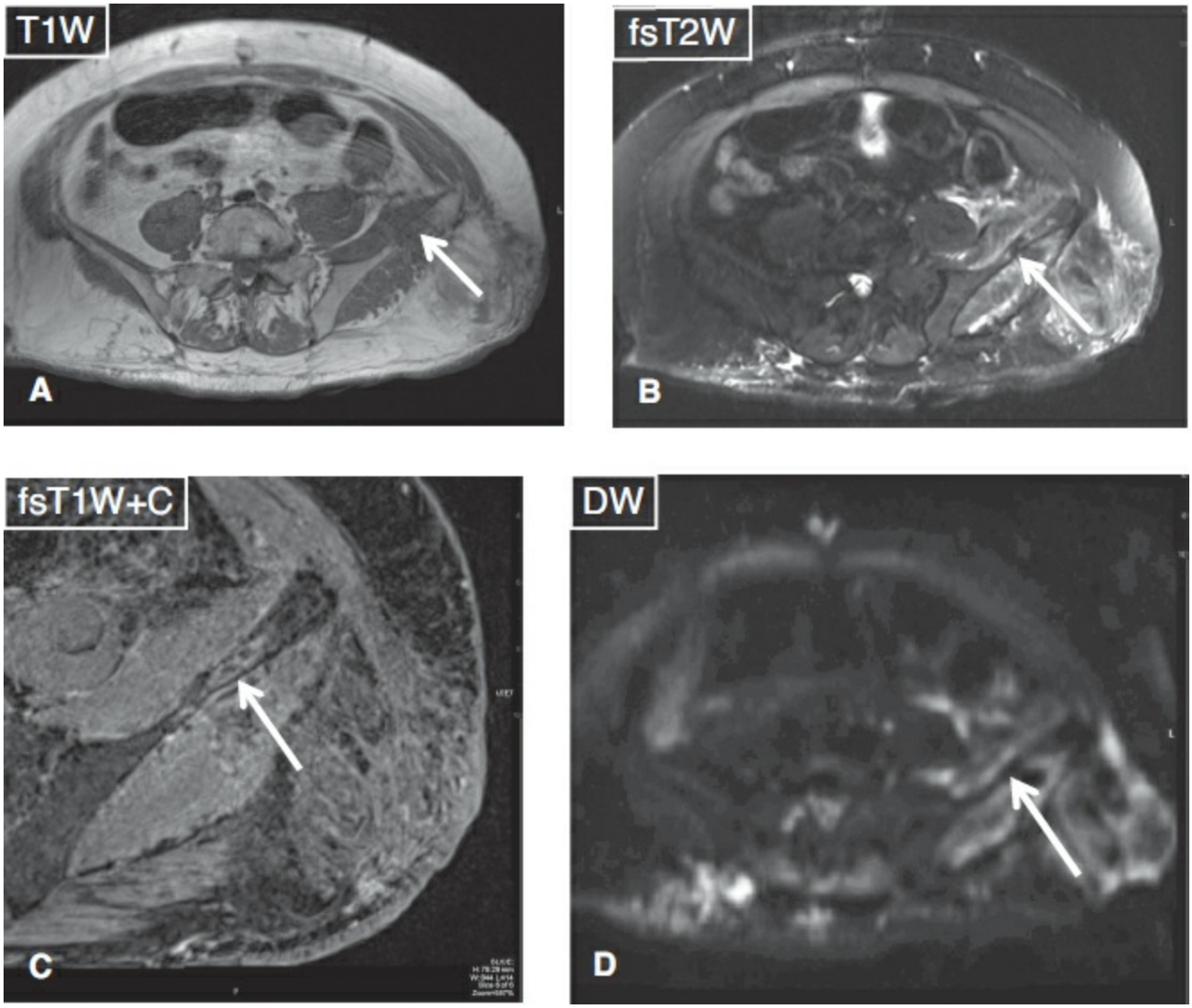

Fig. 10.136: Nonpathologic iliac bone fracture: Conventional axial images (**A**, **B**) reveal a fracture of the left iliac bone (*arrows*) along with soft tissue and fascial edema. In the axial contrast-enhanced (**C**) and diffusion-weighted (**D**) images, there is only peripheral enhancement without restricted diffusion in the involved area (*arrows*).

In infections, the involvement is typically monoarticular and associated with extensive fascial and/or muscle edema and contrast enhancement, joint effusion, fluid collection (with wall enhancement when organized), sinus tract or fistula, as well as relatively diffuse enhancement in coexisting cellulitis or myositis (Fig. 10.137). Chronic recurrent multifocal osteomyelitis (CRMO) may mimic infectious osteomyelitis. Underlying symptoms and serology of toxemia may be minimal, and lesions resolve on anti-inflammatory medications or migrate to other bones.

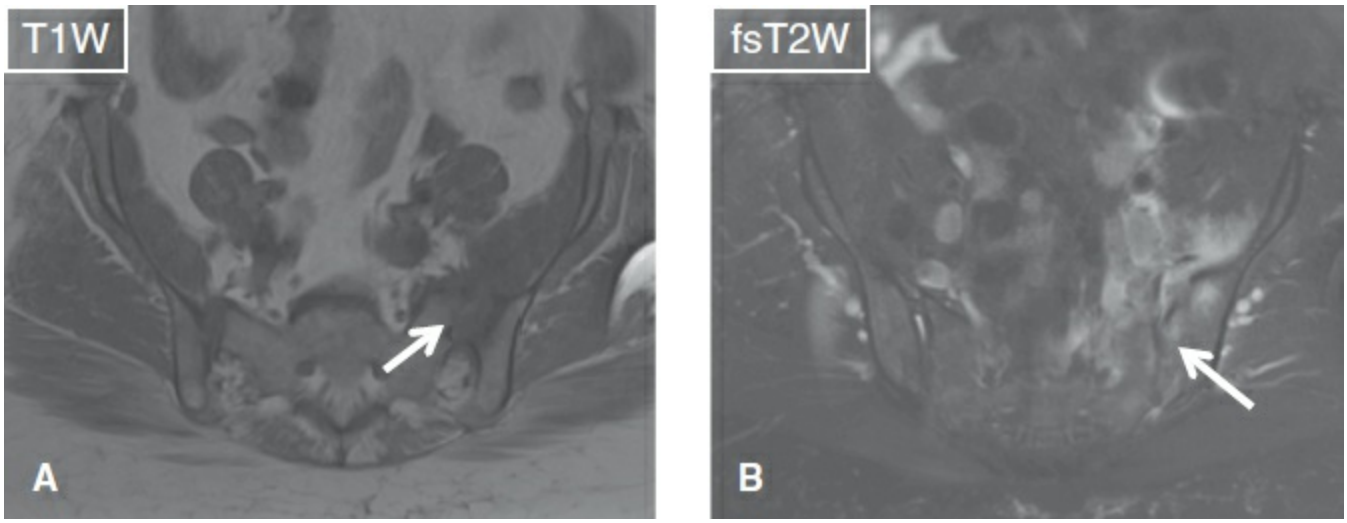

Fig. 10.137: Infectious sacroiliitis: Axial images (**A, B**) exhibit marrow edema of the articular surfaces (*arrows*) of the left sacroiliac joint with surrounding fascial and left iliopsoas muscle edema in this case of tubercular arthritis.