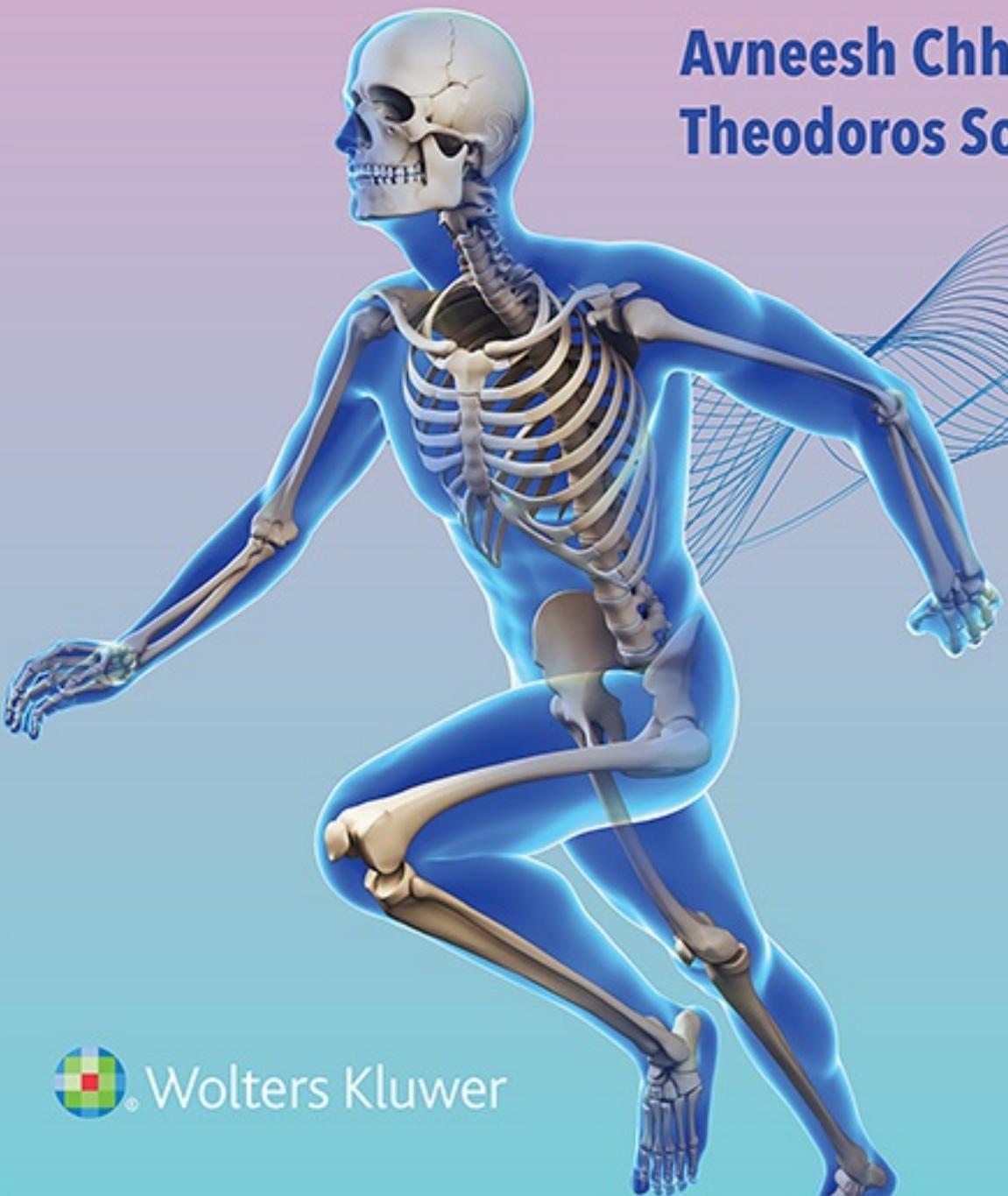


# Musculoskeletal MRI Structured Evaluation

*How to  
Efficiently Fill  
the Reporting Checklist*

**Avneesh Chhabra  
Theodoros Soldatos**



Wolters Kluwer

2nd

EDITION

# Musculoskeletal MRI Structured Evaluation

## HOW TO EFFICIENTLY FILL THE REPORTING CHECKLIST

Second Edition

### EDITORS

#### **Avneesh Chhabra, MD, MBA, FACR**

Professor, Radiology and Orthopedic Surgery

Division Chief, Musculoskeletal Radiology

UT Southwestern Medical Center and Parkland Health

Dallas, Texas

Distinguished Teaching Professor, University of Texas SHINE Academy

Adjunct Professor

The Russell H. Morgan Department of Radiology and Radiological Science

The Johns Hopkins University School of Medicine

Baltimore, Maryland

Walton Center of Neurosciences

Liverpool, United Kingdom

#### **Theodoros Soldatos, MD, PhD**

Consultant Radiologist

Director of MRI Department

Iasis Diagnostic Centre

Kalamata, Greece

Former Musculoskeletal Radiology Research Fellow

The Russell H. Morgan Department of Radiology and Radiological Science

The Johns Hopkins University School of Medicine

Baltimore, Maryland



Philadelphia • Baltimore • New York • London  
Buenos Aires • Hong Kong • Sydney • Tokyo

*Acquisitions Editor:* Nicole Dernoski  
*Development Editor:* Eric McDermott  
*Editorial Coordinator:* Abirami Balakrishnan  
*Marketing Manager:* Kirsten Watrud  
*Senior Production Specialist:* Bridgett Dougherty  
*Manager, Graphic Arts & Design:* Stephen Druding  
*Manufacturing Coordinator:* Lisa Bowling  
*Prepress Vendor:* Aptara, Inc.

Second edition

Copyright © 2026 Wolters Kluwer.

Copyright © 2015 Wolters Kluwer Health.

All rights reserved. This book is protected by copyright. No part of this book may be reproduced or transmitted in any form or by any means, including as photocopies or scanned-in or other electronic copies, or utilized by any information storage and retrieval system without written permission from the copyright owner, except for brief quotations embodied in critical articles and reviews. Materials appearing in this book prepared by individuals as part of their official duties as U.S. government employees are not covered by the above-mentioned copyright. To request permission, please contact Wolters Kluwer at Two Commerce Square, 2001 Market Street, Philadelphia, PA 19103, via email at [permissions@lww.com](mailto:permissions@lww.com), or via our website at [shop.lww.com](http://shop.lww.com) (products and services).

9 8 7 6 5 4 3 2 1

Printed in the United States of America

---

978-1-9752-3406-5

Cataloging in Publication data available on request from publisher.

---

This work is provided "as is," and the publisher disclaims any and all warranties, express or implied, including any warranties as to accuracy, comprehensiveness, or currency of the content of this work.

This work is no substitute for individual patient assessment based upon healthcare professionals' examination of each patient and consideration of, among other things, age, weight, gender, current or prior medical conditions, medication history, laboratory data and other factors unique to the patient. The publisher does not provide medical advice or guidance and this work is merely a reference tool. Healthcare professionals, and not the publisher, are solely responsible for the use of this work including all medical judgments and for any resulting diagnosis and treatments.

Given continuous, rapid advances in medical science and health information, independent professional verification of medical diagnoses, indications, appropriate pharmaceutical selections and dosages, and treatment options should be made and healthcare professionals should consult a variety of sources. When prescribing medication, healthcare professionals are advised to consult the product information sheet (the manufacturer's package insert) accompanying each drug to verify, among other things, conditions of use, warnings and side effects and identify any changes in dosage schedule or contraindications, particularly if the medication to be administered is new, infrequently used or has a narrow therapeutic range. To the maximum extent permitted under applicable law, no responsibility is assumed by the publisher for any injury and/or damage to persons or property, as a matter of products liability, negligence law or otherwise, or from any reference to or use by any person of this work.

[shop.lww.com](http://shop.lww.com)

# Contents

**1 The Process of Structured Reporting: Adding Value and Quality**  
*Avneesh Chhabra and Theodoros Soldatos*

**2 Technical Considerations**  
*Avneesh Chhabra and Theodoros Soldatos*

**3 Infection and Inflammation/Arthritis**  
*Avneesh Chhabra and Theodoros Soldatos*

**4 Bone and Soft Tissue Tumors**  
*Rola Husain, Theodoros Soldatos, and Avneesh Chhabra*

**5 Cartilage**  
*Avneesh Chhabra and Theodoros Soldatos*

**6 The Shoulder**  
*Avneesh Chhabra and Theodoros Soldatos*

**7 The Elbow**  
*Theodoros Soldatos and Avneesh Chhabra*

**8 The Wrist**  
*Theodoros Soldatos and Avneesh Chhabra*

**9 The Hand**  
*Rola Husain, Avneesh Chhabra, and Theodoros Soldatos*

**10 Hip**  
*Avneesh Chhabra and Theodoros Soldatos*

**11 The Knee**  
*Avneesh Chhabra and Theodoros Soldatos*

**12 The Ankle**  
*Theodoros Soldatos and Avneesh Chhabra*

**13 The Foot**  
*Avneesh Chhabra and Theodoros Soldatos*

**14 Magnetic Resonance Neurography**  
*Ali Tejani, Theodoros Soldatos, and Avneesh Chhabra*

**Index**

## CHAPTER 2

# Technical Considerations

Avneesh Chhabra and Theodoros Soldatos

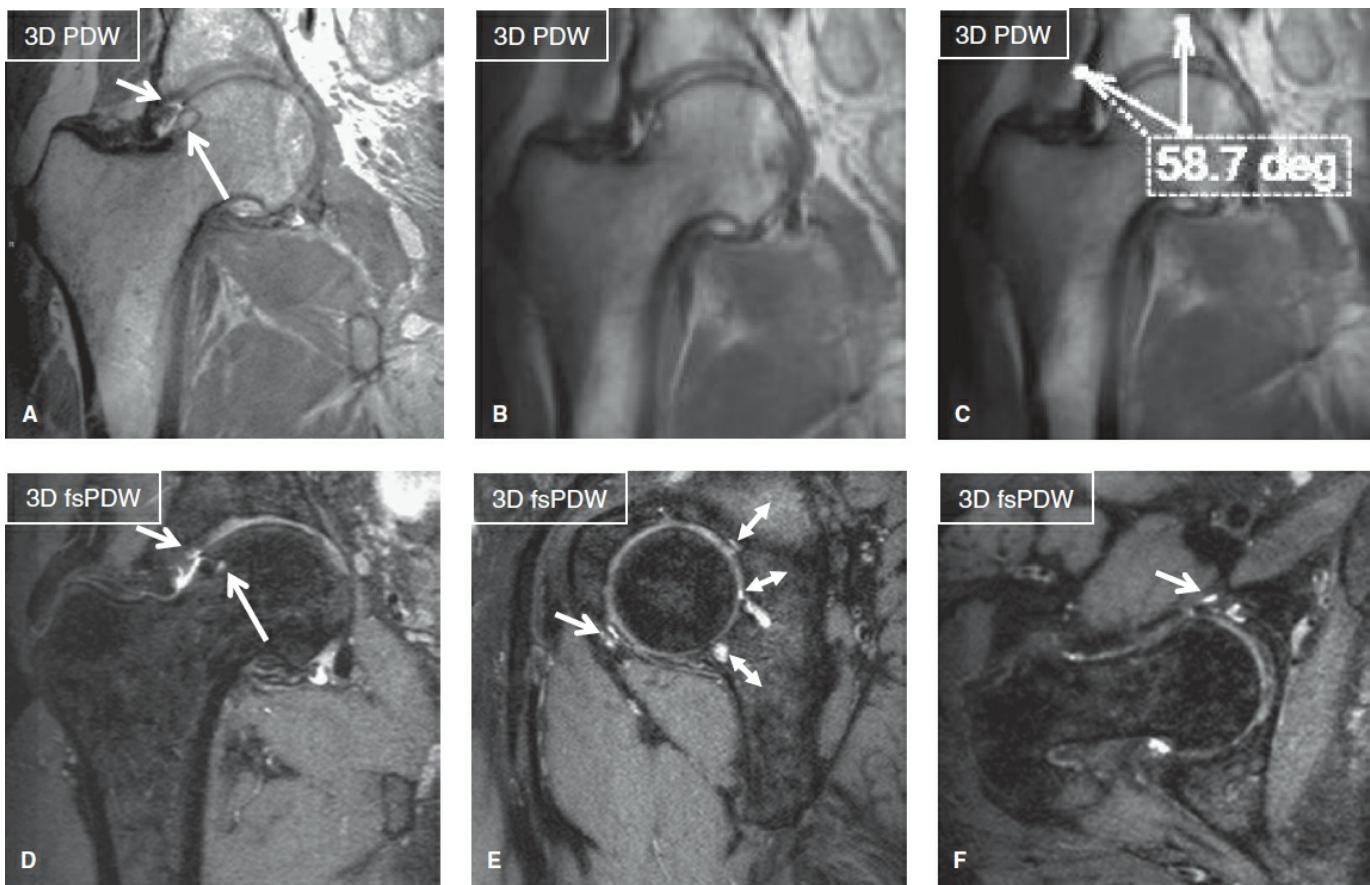
MR imaging is the method of choice for the detection of internal derangements of the various soft tissue structures of joints. Meticulous attention and correct application of various pulse sequences and MR techniques are essential for achieving optimal quality imaging. The latter is essential for superior 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 fibrocartilaginous 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.

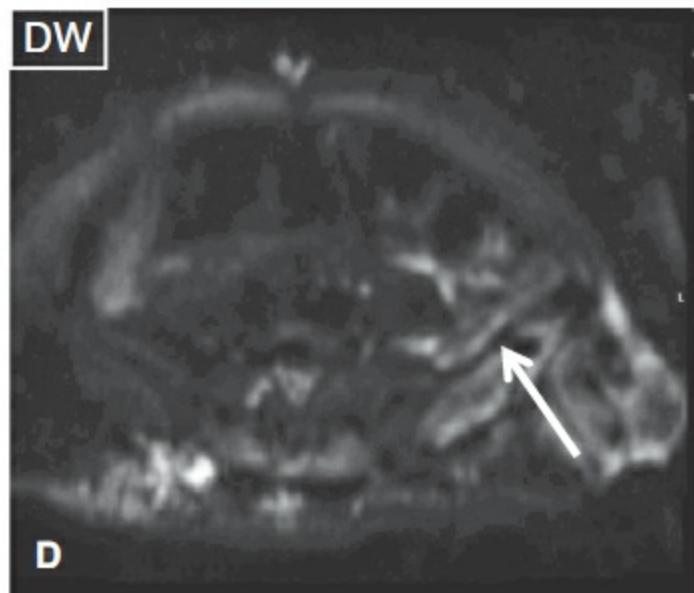
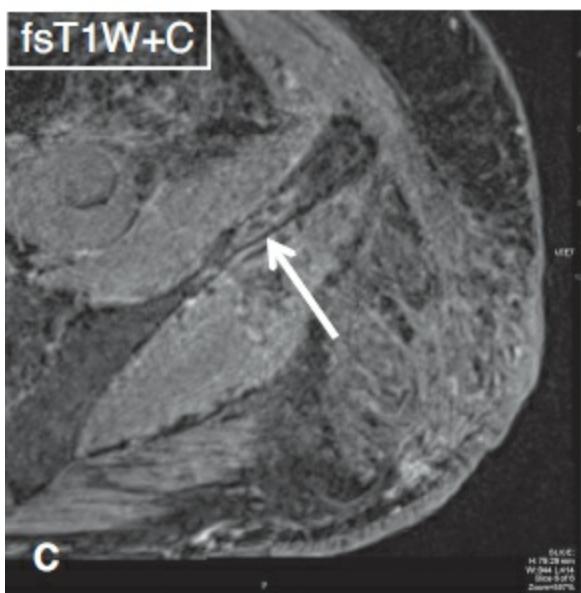
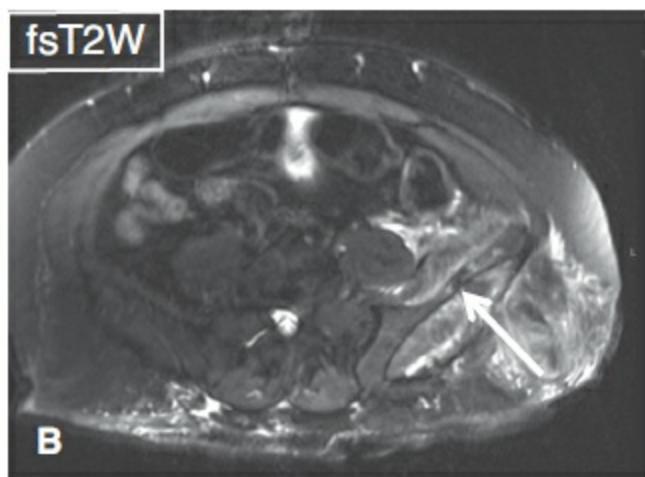
## Patient Coaching

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 snugly 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

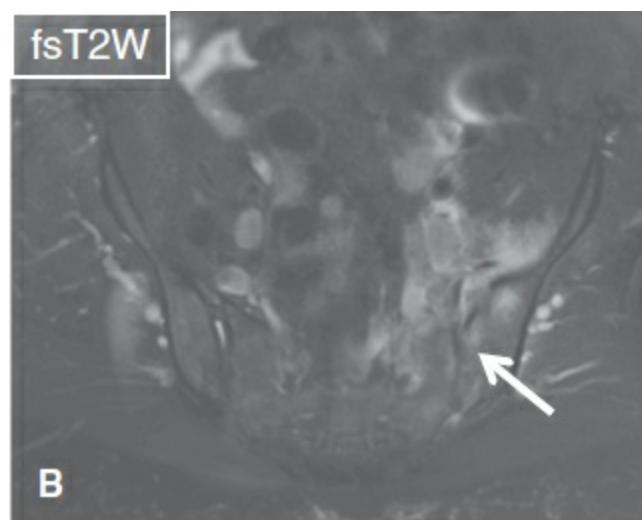
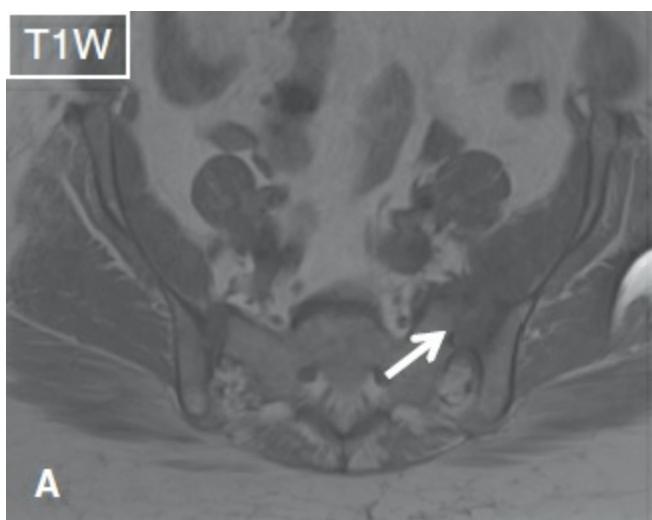
### Scanner Selection

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 sensing 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.