

Musculoskeletal MRI

A Case-Based Approach to
Interpretation and Reporting

Tarek M. Hegazi
Jim S. Wu



Springer

Musculoskeletal MRI

Tarek M. Hegazi • Jim S. Wu

Musculoskeletal MRI

A Case-Based Approach to
Interpretation and Reporting

Tarek M. Hegazi
Assistant Professor of Radiology
Radiology Residency Program Director
Imam Abdulrahman Bin Faisal University
Dammam
Saudi Arabia

Jim S. Wu
Chief, Musculoskeletal Imaging and
Intervention
Associate Professor in Radiology,
Harvard Medical School
Beth Israel Deaconess Medical Center
Boston, MA
USA

ISBN 978-3-030-26776-6 ISBN 978-3-030-26777-3 (eBook)

<https://doi.org/10.1007/978-3-030-26777-3>

© Springer Nature Switzerland AG 2020

This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publisher, the authors, and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, express or implied, with respect to the material contained herein or for any errors or omissions that may have been made. The publisher remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

To my parents, Mohammed and Dalal, for always being there for me; to my late brother, Mahmoud, i miss you so much, to my wife, Nuha for her continuous love and support, without which I would be lost; and to my kids, Mahmoud and Ascia, for making me a better person.

–T.M.H

To Ann, Alex, and Sonie, thanks for everything.

–J.S.W

Preface

The amount of knowledge needed to practice radiology can be daunting. Understanding the nuances of each disorder and knowing the crucial findings to describe for each case in order to guide clinical and surgical treatment effectively can be overwhelming. Moreover, with the ever-increasing demands on radiologists, concise, accurate, and efficient reports are critical. Interpreting musculoskeletal (MSK) MRI studies is particularly challenging since there is complex anatomy and concepts that can be difficult for radiologists, especially for those who are not MSK fellowship trained.

The goal of this book is to teach the reader how to interpret and dictate MSK MRI studies accurately and efficiently through a series of high-yield cases. We have included the most common disorders that you are likely to encounter in your everyday clinical practice. Each case begins with a short clinical history, similar to what could be present on the ordering/requisition form and several carefully selected MRI images. We then provide a concise dictation that highlights the correct terminology to use in order to fully describe the disorder, including the important pertinent negatives of the case. When relevant, we also provide clinical recommendations since many disorders require direct communication with the ordering physician, such as a newly discovered aggressive tumor or certain fractures. Next, we include a detailed discussion of the important characteristics of the case to provide the reader with in-depth knowledge of the disorder. When helpful, we have included relevant normal anatomy images and supplemental cases to help with understanding the details of the case. These discussions are organized similar to the teaching that occurs at workstations with our MSK fellows. Lastly, we provide a “report checklist” to ensure that important findings are included in the final report. The first sets of cases are organized by joint (shoulder, elbow, wrist/hand, pelvis/hip, knee, and foot/ankle). Three additional sets of cases focus on tumor, arthropathy, and miscellaneous conditions. We have also included a section containing normal report templates that can be used to create structured reports for many existing dictation systems.

This book is an ideal guide for anyone who interprets MSK MRI on a regular basis, including general radiologists, MSK radiologists, and MSK radiology fellows/residents. Orthopedic and sports medicine physicians and nurse practitioners will also find this book useful. We hope that this book can be used as a useful reference tool for all readers of MSK MRI.

Introduction

The written radiology report is perhaps the most critical service we provide as radiologists. It is the formal documentation of the findings of each imaging study and consolidates our interpretation of the findings in order to provide a diagnosis or supporting evidence to guide treatment. The importance of the radiology report cannot be understated. It serves as a medicolegal document and is invariably the most important item scrutinized during lawsuits against radiologists. However, we should produce quality reports not out of fear of litigation; but instead, we should create complete and accurate reports out of a desire to perform to the best of our abilities and in order to best treat our patients. Reports can differ in style, understandability, and effectiveness. It can be frustrating for radiologists, referring clinicians, and patients to see poorly worded radiology reports that have limited utility. Although we acknowledge that there is no singular “correct” way to write a radiology report, the ramblings provided below have aided us in our clinical practice over the years, and we hope that you will find some of these points useful in producing concise, complete, and effective MSK MRI reports that fit your style.

Most reports are divided in various subheadings. We like to use five distinct subheadings: Indication, Technique, Comparison, Findings, and Impression. Using subheadings ensures that we do not forget to include certain items in the final report. If a subheading is listed in the report template, you are less likely to forget to include important information. Also, many dictation systems can autopopulate a variety of information directly into the report, such as the study name, patient demographics, and clinical history. Depending on your referral base, it can be a good idea to discuss your report subheadings and style with your most common referring orthopedists and physicians in order to arrive at a mutually helpful reporting style.

The indication for the study should always be included in the report. Oftentimes, the provider may provide a useless history such as “pain” or “r/o pain.” However, we should not take out our frustration on the patient and simply read the study with limited clinical information. We are more likely to miss an important finding if we do not know their complete history. It is important to review the clinical notes to determine the specific injury and symptoms leading to the reason for the MRI. Often, the assessment and plan of the last clinical note will state the reason for the MRI. Moreover, it is of utmost importance to determine if a patient has had prior surgery, which can prevent the radiologist from appearing careless and, at worse, incompetent. This is especially true for knee MRI exams. For instance, after meniscal repair, there can be abnormal signal contacting an articular surface that can be a normal postoperative finding for several years. However, in a native meniscus, the same appearance could constitute a new tear. In the shoulder, a common mistake is to report a biceps tendon rupture in someone with a biceps tenodesis or tenotomy. Knowledge of prior treatments and procedures is also important. We have seen bone marrow aspiration sites being mistakenly reported as tumors and gas in a joint from recent joint aspiration being overcalled as an acute septic joint. Knowing more information about the patient

will only help you in interpreting the MRI exam. Moreover, we should always answer the clinical question given to us by the referring clinician. Read it! If the requisition asks to “evaluate for lymphadenopathy” on a routine shoulder MRI exam, then be sure to include the presence or absences of lymphadenopathy in the Findings and Impression sections of the report. If the provided clinical history specifically asks if there is osteonecrosis on a routine hip MRI, then be sure to comment on this in the final report. There have been numerous times when we have reread the indication and realized that the exact disorder is actually present. This often occurs when the findings are not part of our routine search pattern.

For the Technique section, we like to keep it short but informative as to what MR protocol was used. Most institutions have specific protocols for different indications: routine knee, tumor/infection, Morton’s neuroma, or pectoralis tear protocols are some examples. Including the protocol and actual MR sequences can aid in future protocols for comparison studies and to document the use of intravenous or intra-articular contrast. Occasionally, special sequences such as in-and-out-of-phase images or diffusion-weighted images maybe performed to help elucidate certain findings.

The Comparison section should always be included, mostly as a reminder for us to look at old studies. For every case, we should either (1) compare to a prior study; (2) compare to the prior report, if the images are not available; or (3) state that there are no comparison exams. At times, patients are referred to our institution for MRI due to findings seen on outside hospital imaging studies. We make a point to state in this section that those outside hospital films are not available to us in the Comparison section. Furthermore, many PACS systems will bring up old comparison studies when the study is “launched.” However, this can be misleading depending on how the studies are coded in the PACS system. Slight variations can make an appropriate old study not appear as a comparison, making the radiologist think that there are no comparison studies. We make a point to quickly look at the entire list of cases in the patient’s folder to be sure the old comparison studies are reviewed. You should also look for studies that may not be identical but will include the anatomic area of interest. For instance, sagittal images from a CT scan of the abdomen and pelvis are excellent for evaluating the spine and sacrum. CT scans of the chest can include portions of the shoulders and are very helpful in diagnosing calcific tendinitis or loose bodies. Comparison studies can greatly aid in determining whether a finding is new and worrisome or old and of doubtful clinical significance. Seeing the identical finding unchanged over several years is often reassuring.

The Findings subheading is the meat of the report. In this section, one should comment on the important anatomic structures of each MRI exam, both abnormal findings and pertinent negatives. We find it helpful to divide this subheading into anatomic parts in order to ensure that each structure is reviewed carefully and completely. Structures are often listed in order of most importance or commonly abnormal areas. For instance, in the shoulder, we start with the rotator cuff; and in the knee, we start with the menisci. In this subheading, each finding should be described clearly. Personally, we prefer full sentences as opposed to sentence fragments; however, this is personal

preference. If using full sentences, try to avoid exceedingly long run-on sentences. Remember that these reports will be read by many people including your colleagues, referring physicians, and patients. It is important to be definitive when possible without using ambiguous terms. When appropriate, give the actual dimensions of the findings, such as the size of an enlarged tendon, soft tissue mass, or ganglion. This can help the reader understand the severity of the process or lesion. When it is not possible for actual measurements, quantifying findings as mild, moderate, or severe can be helpful, such as “mild degenerative changes of the tibiotalar joint,” “moderate tendinosis of the quadriceps tendon,” or “severe tenosynovitis of the posterior tibialis.” For each important finding that can impact patient care, it is important to comment on whether it was present on prior studies, as this will affect the final conclusion and whether treatment is needed.

The last subheading of the report is the Impression and is the culmination of your thoughts and your synthesis of the case. Past studies have shown that only the Impression of the radiology report is read by referring physicians in 40–50% of the time. This is clearly not ideal for patient care as important information can be found in the Findings subheading, but it does highlight the importance of the Impression section. Note that this subheading is not called Diagnosis. The Impression is exactly your impression of what is occurring in the patient based on your assessment of the imaging findings and clinical history. Oftentimes, an actual diagnosis cannot be made, so it would be inaccurate to have a Diagnosis section for each report. In these cases, a differential diagnosis may need to be given. For instance, if you see nonspecific marrow edema in the femoral head, this could represent infection, tumor, trauma, or a myriad of other disorders. It is of no use to the reader to simply list a whole slew of disorders without guidance as to which one is most likely to be the cause of the patient’s symptoms. Give the most likely diagnosis first, and then discuss the other less likely disorders next. This is your impression, not something that is set in stone. Also, avoid listing new items in the impression. Any item in the Impression should have been discussed in the Findings subheading. Lastly, it is important to make any recommendations based on your impressions of the case, and this may require direct communication with the referring physician or medical provider. For instance, a new stress fracture on the tensile side of the femoral neck should be directly discussed with referring physician and recommendations for limited weight-bearing be made so that the patient does not complete the fracture. A newly discovered aggressive tumor should also be communicated and recommendations on whether the lesion is amenable to percutaneous biopsy be made. Oftentimes, these are common sense questions that the referring physician will need to know, and good radiologists will anticipate these questions and answer them in the report.

Hopefully, these tips will help you in interpreting MSK MRI studies and generate quality reports. Again, we realize that there are many ways to write a radiology report, and each radiologist will arrive at his or her own style, often changing it throughout their career. It could be argued that the basic aspects of the radiology report could be summarized in this quote by Leonard Berlin, Professor of Radiology at Rush University and the University of

Illinois, Chicago: “You should ask yourself four questions: what do I see on the images, what do I think the findings mean, what do I want the referring physician to conclude from my report, and what do I think the referring physician should do next.” Now on to the cases!

Dammam, Saudi Arabia
Boston, MA, USA

Tarek M. Hegazi
Jim S. Wu

Acknowledgments

This book would not be possible without the assistance and guidance of my many mentors, colleagues, and friends. I would especially like to thank Andrew Haims, Lee Katz, Neil Rofsky, Wing Chan, Ferris Hall, Seward Rutkove, Mary Hochman, Corrie Yablon, Colm McMahon, Jennifer Ni Mhuirheartaigh, Justin Kung, Suzanne Long, Daniel Siegal, Yu-Ching Lin, Yulia Melenevsky, Ron Eisenberg, Clotell Forde, and of course my coauthor Tarek Hegazi. I would also like to thank all the residents and fellows that I have had the pleasure of teaching. Seeing their enthusiasm for our specialty and watching them mature as radiologists provides me with great joy.

Jim S. Wu

I would like to thank all the attending staff at the MSK division of Thomas Jefferson University, especially Diane Deely, Bill Morrison, Adam Zoga, Suzanne Long, Kristen McClure, Paul Read, and Johannes Roedl. It has been a privilege to work with such a talented and creative group. I would also like to thank Jim Wu for agreeing on taking this endeavor of writing this book together and for his continuous support and guidance throughout this journey. Lastly, to my residents and fellows from whom I learn everyday, Shukran!

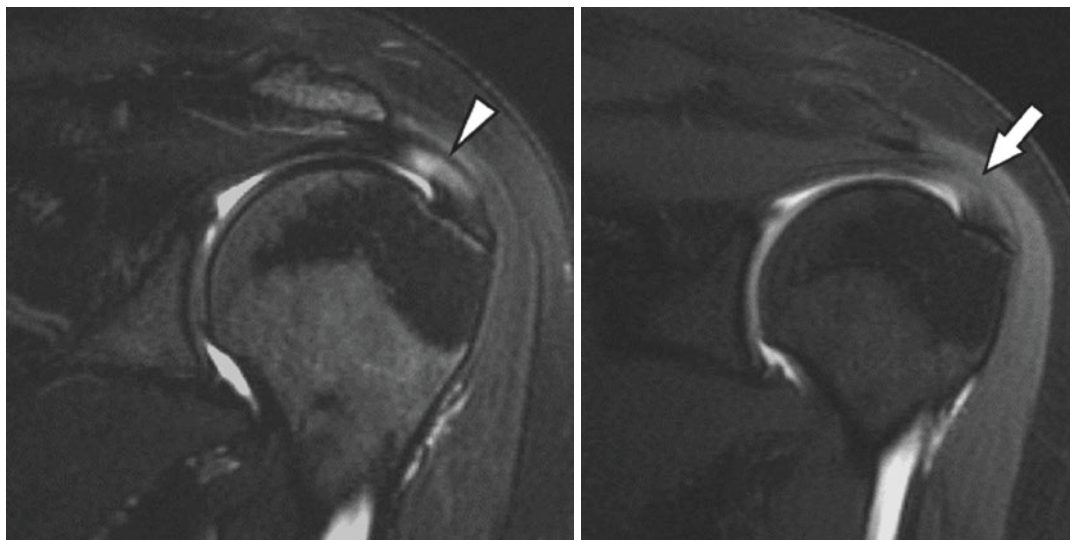
Tarek M. Hegazi

Contents

1	Shoulder	1
2	Elbow	35
3	Wrist/Hand	55
4	Pelvis/Hip	81
5	Knee	109
6	Ankle/Foot	161
7	Tumor/Tumor-Like Lesions	203
8	Arthropathy	231
9	Miscellaneous	253
10	Sample MSK MRI Reports	277
	Index	297

Case 1.1

Indication A 37-year-old woman with nontraumatic right shoulder pain. Evaluate for rotator cuff tear.



Coronal T2 fat saturated

Coronal T1 fat saturated arthrogram

Findings

On the T2-weighted images, there is hyperintense signal in the supraspinatus tendon just proximal to its footprint (arrowhead) compatible with moderate tendinosis. The signal intensity is not as bright as fluid, thus excluding a focal tear. On the T1-weighted post-arthrogram images, there is no contrast extending into the tendon

substance (arrow) to indicate an articular surface tear. There is no fluid in the subacromial/subdeltoid bursa. There is no subacromial spur or os acromiale.

Impression/Recommendation

Tendinosis of the supraspinatus tendon without focal tear.

Discussion: Rotator Cuff Tendinosis

The rotator cuff (RTC) is made up of four separate muscles and tendons that act to stabilize the shoulder. They consist of the supraspinatus, infraspinatus, teres minor, and subscapularis tendons. They arise from the scapula and join on the tuberosities of the humeral head. The footprint of the supraspinatus tendon inserts onto the superior facet of the greater tuberosity, just posterior to the bicipital groove. The infraspinatus tendon footprint is much larger, and the anterior fibers of the infraspinatus tendon interdigitate with the posterior fibers of the supraspinatus tendon and insert on the posterior aspect of the superior facet. The remainder of the infraspinatus tendon inserts onto the middle facet of the greater tuberosity. The teres minor tendon inserts on the inferior facet. The subscapularis tendon is multipennate and inserts broadly on the lesser tuberosity. On MRI, the normal RTC tendons show uniform hypointense signal intensity on all pulse sequences since they are composed of dense collagen bundles. The supraspinatus and infraspinatus tendons are best evaluated on the coronal and sagittal oblique sequences, while the subscapularis and teres minor tendons are best assessed on the axial and sagittal sequences.

RTC tendinosis refers to chronic degeneration of the tendons. The exact etiology is controversial, with two common theories. In the extrinsic theory, there is external impingement of the subacromial bursa and the bursal surface of the rotator cuff by hypertrophic changes of the acromion (subacromial spur), osteophytes from the acromioclavicular joint, type 3 (hooked) acromion, or an os acromiale. In the internal theory, intratendinous degeneration of the tendons occurs due to advancing age and chronic overuse. RTC tendinosis is a common finding seen on routine MRI of the shoulder and may or may not be associated with shoulder pain. On MRI, RTC tendinosis appears as mild to moderate diffuse thickening of the tendon and diffuse intermediate signal intensity within the substance of the tendon on T1- and T2-weighted images. It is important to

differentiate tendinosis from low-grade partial tears. The T2 signal intensity in RTC tendinosis should not reach the intensity of fluid signal, while tendon tears should demonstrate fluid signal intensity. This is best seen on a T2-weighted fat-suppressed sequence. One should compare the signal intensity in the tendon with fluid in the joint space or subacromial/subdeltoid space. Furthermore, the signal in RTC tendinosis is more globular and typically less linear in appearance than the signal abnormalities seen in RTC tears. Tendinosis is often associated with fluid in the subacromial/subdeltoid bursa indicating bursitis. Moreover, there has been confusion about the terms: tendinosis, tendinitis, tendinopathy, and tendonitis. Tendinosis is tendon degeneration due to chronic overuse, whereas tendinitis indicates inflammation of the tendon with an inflammatory response, often due to microtears or arthropathies. Tendinopathy is the broader term that includes both tendinosis and tendinitis. We have used the term tendinosis here as it is likely the more common process occurring in rotator cuff pathology, but the term tendinopathy would also be appropriate. Tendinosis and tendinitis cannot be distinguished based on imaging. Lastly, tendonitis is simply a misspelled word and should not be used; however, it is unclear why the “o” was replaced by the “i” in these terms (see Suggested Reading).

Most patients with RTC tendinosis respond well to physiotherapy, nonsteroidal anti-inflammatory medication, and heat/ice therapy. Infrequently, surgery may be required.

Report checklist

1. Which rotator cuff tendons are involved?
2. What is the degree of tendinosis (mild, moderate, or severe)?
3. Is there an associated rotator cuff tear (i.e., is there fluid signal in the tendon substance)?
4. Are there findings to suggest external impingement (subacromial spurs, os acromiale, hooked acromion, or inferior osteophytes with acromioclavicular joint osteoarthritis)?
5. Is there subacromial/subdeltoid bursitis?

Suggested Reading

- Ahmad Z, Ilyas M, Wani GM, Choh NA, Gojwari TA, Ahmad Kazime MJ. Evaluation of rotator cuff tendinopathies and tears with high-resolution ultrasonography and magnetic resonance imaging correlation. *Arch Trauma Res.* 2018;7:15–2.
- Kyff R. Who took tendon out of tendinitis? *The Hartford Courant.* 8 Mar 2000.
- McMonagle JS, Vinson EN. MRI of the shoulder: rotator cuff. *Appl Radiol.* 2012;41:20–7.