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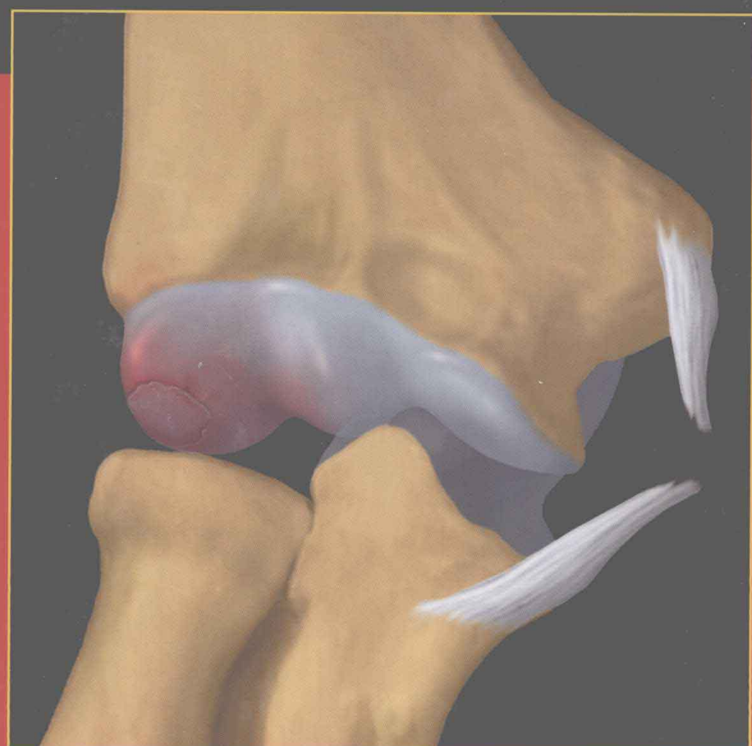
MUSCULOSKELETAL: TRAUMA



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MUSCULOSKELETAL: TRAUMA

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With love to my book-widow Karen and my beautiful and patient children Kaitlyn, Aaron, and Evan.

Also, a special thank you to those who have provided extraordinary education, opportunity, and encouragement through my career: Jeremy J. Kaye, Lee F. Rogers, Steve W. Fitzgerald, Mark J. Murphey, and B. J. Manaster.

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RH

PREFACE

When I was presented with the opportunity to write *Diagnostic Imaging: Musculoskeletal Trauma* for Amirsys, it quickly became apparent that this was an opportunity to create the book that I had always wanted on my own reading room bookshelf: A comprehensive work covering all areas of orthopedic trauma and sports medicine imaging. Instead of relying on one book to reference the grading system of distal femoral fractures and another to refresh my memory on all the variants of SLAP lesions of the shoulder, this book has it all.

This book maintains the successful bulleted-text format used in other Amirsys texts, providing concise but complete information on a very wide range of topics in orthopedic trauma and sports medicine imaging. Thousands of never-before published case images provide state-of-the-art image quality throughout the full breadth of pathology discussed. Hundreds of eye-popping full-color illustrations enhance the visual nature of the book and are used to demonstrate the three-dimensional nature of pertinent anatomy and pathology, such as fracture classification systems. References are up-to-the minute, and information in the text reflects this.

Each clinical section has been written by a recognized expert in the field. The result is not only a body of information reflecting the voice of experience, but a collection of some great illustrative examples of the pathology discussed in each chapter. Rather than simply providing one “classic” example of each type of pathology, we have striven to provide examples of common and unusual variants that may be encountered in clinical practice. An introductory chapter for each anatomic region provides the author’s perspective on the anatomic and imaging issues relevant to that region.

Another benefit to the expanded format of this book is the huge collection of supplemental online material found in Amirsys eBook Advantage™; even in a book of this size, some information could not be included in the printed version. Every chapter is associated with additional illustrative cases, and in many cases, significant additional text and references. Besides the supplemental material, all of the material contained in the hard copy of the text is included in the online version, which means that you will have a copy of *Diagnostic Imaging: Musculoskeletal Trauma* available to you wherever you can access the web!

We think that you will find this text an invaluable asset in your clinical practice. We have made every attempt to make this book relevant, easy to use, and visually stunning. It should appeal to both the seasoned subspecialist musculoskeletal radiologist and the junior radiology resident, and everyone in between. We hope you agree.

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SECTION 1
Introduction

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Traumatic Injury, Special Topics

INTRODUCTION TO TRAUMATIC INJURY

Purpose

This volume is designed to describe and illustrate the gamut of traumatic and sports-related injuries to the extremities encountered in the practice of radiology. Emphasis is placed on imaging patterns and the interrelation between and critical differentiation among entities, so that the reader may quickly focus on the most appropriate imaging features, descriptive language, and differential diagnosis for the entity at hand. Images and illustrations are organized in order to display the range of appearance for each entity, including potential complications and postoperative appearance. References at the end of each chapter provide the reader with additional avenues of exploration if desired.

Terminology

Anatomic terminology used in this book follows conventional medical literature guidelines. For example, the radial aspects of the elbow, forearm, and wrist are termed "lateral" and the ulnar aspects "medial." The terms "superior" and "inferior" have been used to indicate direction in the z-axis of the body instead of "cephalad" and "caudad." The term "mesial" is used to indicate direction toward the center of a limb but not necessarily the center of the body. Specific terminology used for each anatomic region is described in the introductory chapter for that section.

A variety of acronyms are found in the medical literature to refer to injury patterns, imaging findings, and operative approaches. Commonly used acronyms are presented in this book but are spelled out on their first use in each chapter.

The commonly encountered clinical entity of tendon injury is described in this book using the term "tendinopathy," as opposed to "tendinosis" or "tendinitis." This is based on the etymologic origins of these terms. The suffix "-osis" refers to "a process, condition, or state" without being terribly specific about what the process is. The suffix "-itis" refers to "inflammation of"; thus the term "tendinitis" may be appropriate in rare circumstances in which the tendon is inflamed due to acute trauma or infection. However, most cases of tendon pathology encountered in sports imaging are the result of a process of chronic repetitive microinjury and repair, resulting in a weakened tendon unit that is more prone to macroscopic tear. This process has been termed "angiofibroblastic hyperplasia" and is characterized by ingrowth of fibroblastic repair tissue and neovascularity; there is very little inflammatory component. Thus the suffix "-opathy," meaning "disease or disorder of," most accurately describes the underlying process.

Although the imaging of some areas (e.g., the shoulder) typically requires nonorthogonal imaging planes to provide anatomically appropriate images, the terms "coronal" and "sagittal" have been used to imply "oblique coronal" and "oblique sagittal" planes conventionally used in those regions. When a nonconventional obliquity is illustrated, a description of the imaging plane used is provided. The terms "CT" and "MR" have been used throughout the book to indicate "computed tomography" and "magnetic resonance" imaging techniques.

Anatomy-based Imaging Issues

For the sake of consistency, images have been presented so that they appear as "right-sided" throughout the book. Thus, all radiographs, CT and MR images, and graphic illustrations will share a uniform orientation for easier correlation between different examples and modalities. This was not done for cases involving the pelvis and chest in order to maintain anatomic relevance.

Imaging Protocols

While some specific description is provided for the acquisition of certain radiographic views, description of most CT and MR imaging techniques is given only in general terms. This was done with the understanding that imaging equipment from different manufacturers, and often different levels of equipment from the same manufacturers, have very different capabilities and use a wide range of descriptive language to provide similar imaging results. Thus, terms such as "T2-weighted fat-suppressed MR images" describe the generic appearance of anatomy that may be accomplished using a wide variety of proprietary MR techniques. In addition, the armamentarium of imaging techniques changes constantly, and new pulse sequences and hardware devices become available that may alter the method used by a particular radiologist to accomplish the same end.

In general, CT imaging of joints or extremities is best accomplished using a multislice scanner to acquire very thin slices through the affected anatomic region, with subsequent creation of anatomically appropriate reformatted images in additional planes from the acquired data. To avoid reconstruction artifact in small joints, a minimum of 6 to 8 detector rows is advisable, and more pleasing images are produced with higher detector counts (typically 32 to 64).

MR imaging of joints and extremities is best accomplished using volume coils in order to maximize signal-to-noise ratio of the images and minimize field inhomogeneity that may hinder or prevent chemical fat suppression. Joint-specific volume coils are available from most magnet manufacturers for commonly imaged anatomic regions. Optimization of images is usually a trade-off between minimizing the field-of-view to cover the area of interest and the maintenance of appropriate signal-to-noise on the images through manipulation of pulse sequence parameters. The increasing availability of multichannel extremity coils and higher strength magnets provide greater opportunity to improve both of these goals simultaneously.

The use of gadolinium arthrography can be very helpful in the detection and description of certain intraarticular pathologies. The application of this technique is described and illustrated where appropriate. This may be accomplished by direct injection of the joint (direct MR arthrography) or by intravenous injection of gadolinium followed by delayed MR imaging of the joint (indirect MR arthrography). Direct arthrography has the advantage of distending the joint but is invasive. Indirect arthrography is less invasive but provides no joint distension and may result in enhancement of tissues (such as a hyperemic but intact rotator cuff) that can confuse image interpretation.

The clinical utility of ultrasound in the evaluation of musculoskeletal injury continues to grow and is currently an area of intense research and publication. Ultrasound can provide exquisite anatomic detail of soft tissues, particularly in areas close to the body surface; because the ultrasound beam deteriorates with the depth of tissue it needs to penetrate, technical limitations are often encountered in the evaluation of deeper structures (and particularly in large patients). The technique uses no ionizing radiation and is noninvasive. However, musculoskeletal ultrasound is heavily dependent on operator skill, and a steep learning curve may be encountered as one seeks to gain expertise in this field. In geographic regions where access to MR imaging is limited, musculoskeletal ultrasound has grown to be a reliable and ubiquitous problem-solving imaging modality. In most of the United States, probably because of the relative availability of MR imaging in most communities, the use of ultrasound in the imaging diagnosis of sports injury lags behind that in other parts of the world.

Pathologic Issues

In many cases, the manifestations and etiologies of trauma and injury are very different for children than they are for adults. Description and illustration of issues specific to pediatric patients is provided where appropriate. Dedicated chapters are presented on the topics of child abuse and physeal injuries.

Orthopedic surgeons commonly use classification and grading systems to categorize injuries. These systems are usually helpful in determining appropriate therapy for a particular injury. The commonly used classification and grading systems for each injury are provided and illustrated.

Pathology-based Imaging Issues

Each chapter contains discussion of the advantages and disadvantages of particular imaging techniques in diagnosing and characterizing a particular entity. Some generalizations may be made, however.

Radiography is usually the 1st-line tool in the evaluation of acute traumatic injury to the limbs, primarily as a way to detect fractures and dislocations. Soft tissue injury is much less well delineated on radiographs, however, and the information provided regarding the soft tissue components of an injury tends to be nonspecific.

CT, because of its superior tissue density differentiation, can be more helpful in detecting and characterizing some soft tissue findings, but its clinical utility is mainly based on evaluation of osseous abnormalities. Small fractures are generally better demonstrated on CT than on radiographs because of the former's tomographic nature, which alleviates confusion due to overlapping structures. The addition of contrast arthrography to CT can be helpful in evaluating certain intraarticular structures and provides value in the detection of rotator cuff tear, labral injury in the shoulder and hip, meniscal injury in the knee, and cartilage injury throughout the extremities.

MR imaging uses a strong magnetic field and radiofrequency energy pulses to manipulate the energy state of protons within tissue. Complex machinery detects subtle differences in how different tissues respond to this energy deposition and provides exquisitely detailed information about soft tissues. For this reason, MR imaging has been the mainstay of diagnosis in acute and chronic injury to soft tissues, such as ligaments, tendons, and muscles. In addition, MR can provide detailed evaluation of intraarticular structures, often without the injection of contrast material, so that fibrocartilage (meniscus and labrum), chondral cartilage, and synovial pathology is well demonstrated. There are some specific situations in which the use of intraarticular contrast injection can increase the diagnostic accuracy of MR, such as in the postoperative patient. MR imaging also provides a sensitive method for the detection of bone marrow abnormalities, such as marrow edema, osteonecrosis, and tumor infiltration, but is not particularly sensitive for disruption of cortical bone unless a fracture is displaced.

Ultrasound provides another excellent method for studying the soft tissues of the extremities, and, as indicated above, is particularly useful in the evaluation of structures close to the skin surface. In addition, ultrasound provides real-time information regarding the motion of structures and is thus valuable in the evaluation of transient phenomena, such as tendon impingement or subluxation. Limitations of ultrasound include the inability of the beam to penetrate dense material, so that bone and metal effectively block the evaluation of anything located deeper in the body. For this reason, ultrasound is not commonly useful for the evaluation of intraarticular pathology. Ultrasound also does not perform well when encountering air collections, since sound waves travel poorly through air.

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