Medical Imaging for the Health Care Provider
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Medical Imaging for the Health Care Provider

Practical Radiograph Interpretation

THERESA M. CAMPO, DNP, FNP-C, ENP-BC, FAANP

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I dedicate this book to my husband Jonathan. You never cease to amaze me with your support, encouragement, guidance, and, most of all, love. This book would not have come to fruition without you! You are the reason I wake up in the morning, you are the love of my life, and you are my best friend and soul mate. God certainly blessed me with you.
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Foreword

When the medical professional is confronted with interpreting his or her own x-ray studies, the task can seem daunting. In her new book, Medical Imaging for the Health Care Provider: Practical Radiograph Interpretation, Dr. Theresa Campo reduces the seemingly overwhelming task into manageable, logical steps. She literally takes you through the ABCs of interpretation. The information is relevant, practical, and immediately applicable to the modern medical provider.

If that weren’t enough, Dr. Campo also is able to provide insight into the sometimes confusing alphabet soup of imaging, giving real-world guidance in how and when to order an ultrasound, MRI, and CT. By expertly explaining the hows and whys of imaging, she provides you with a powerful tool for understanding what to order for your patient, rather than reverting to a laundry list that you can never remember or never seems to exactly be applicable to the situation you are in.

These insights, along with a thorough knowledge of relevant terms and vocabulary that is so necessary in communication among medical professionals, makes this book one you will want to have by your side every day you are working. I know you’ll enjoy and appreciate Medical Imaging for the Health Care Provider.

David Begleiter, MD
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Preface

Welcome to Medical Imaging for the Health Care Provider: Practical Radiograph Interpretation. I prepared this book after I discovered a lack of suitable resources I needed to teach classes to nurse practitioner and physician assistant students in medical imaging and interpretation. I simply wanted to share the excitement I have for this topic with my advanced practice, interdisciplinary colleagues and help them understand the dynamics of the five testing modalities and approaches to interpretation of radiographs. I truly believe this book can be useful to all health care providers, whether students or practicing providers, in a wide range of clinical settings.

The intention of this book is to provide a concise, easy-to-use reference that introduces the reader to differences in medical imaging testing modalities and teach the basics of plain radiograph interpretation. It is designed to assist providers in identifying and understanding the various medical imaging testing modalities of radiographs, CTs, nuclear imaging, MRIs, and ultrasound scans and images. The book presents written descriptions of the various modalities that are enhanced with figures, tables, and actual patient films. The text demonstrates concepts and discusses in clearly presented language the various attributes of the range of testing modalities and how to interpret them. This approach helps to deepen the practitioner’s understanding of the differences in the modalities, along with a deeper appreciation for the parameters of these tests, and supports appropriate utilization of these diagnostic tools when diagnosing patients.

This book is divided into four units. The first unit introduces the reader to the history of medical imaging and gives an overview of radiology and each testing modality. Guidance is provided on how to choose the best diagnostic medical imaging test to assess the presenting condition. Units II through IV cover interpretation of plain radiographs of the chest, abdomen, extremities,
and spine. Age-appropriate considerations are included throughout the book, as is the importance of the clinical decision-making process. The reader may also access the images and drawings found in this text at springerpub.com/campo-medical-imaging.

Interpretation of plain radiographs can be challenging and frustrating for any provider, whether a student or novice. The simplified approach to interpretation is performed step by step utilizing the ABCs of interpretation. Having fail-safe measures in place, learning to interpret what you are seeing on the radiograph, and understanding the rationale underlying your interpretation will assist you in confidently diagnosing the patient. Whether you are reading a radiology report or interpreting radiographs, this important resource will help build your confidence in your ability to read and interpret radiographs. It will help you feel more self-assured and less stressed. So let’s get started and have fun!

Theresa M. Campo
Acknowledgments

One person cannot move mountains or accomplish goals by himself or herself. My family, friends, and colleagues have helped me to accomplish my goal of publishing this book. I would like to say thank you for your continued support!

Dad, I want to thank you for the unconditional support you give me. You mean the world to me and I am so blessed with the relationship we have grown into. You are not only my father but a person I look up to and admire.

Atlantic Medical Imaging—radiology group—thank you for all of your support and guidance in developing and completing this book. Dr. David Begleiter, especially—thank you for all of your guidance, expertise, support, encouragement, and most of all the patience you gave me during the journey in completing this book.

Margaret Zuccarini and Springer Publishing Company—thank you for allowing me the opportunity to share my love for medical imaging with my colleagues.

I would like to thank the following individuals for assisting with illustrations and images. You were more than instrumental in making this book complete.

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I would like to thank Heather Cox and the students from Ocean City High School who provided the awesome drawings for this book.

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This chapter introduces and briefly discusses the different radiological testing modalities that use ionizing radiation. The section on each testing modality describes how the images are obtained by the various machines and technology, their uses and benefits, as well as downfalls associated with each modality. This allows for differentiating the various modalities, but also gives an appreciation for how the images are produced. Knowledge of the various testing modalities is fundamental in understanding the most cost-effective and appropriate diagnostic studies for suspected conditions.

RADIOGRAPHS

Radiographs have been used for more than a century, revolutionizing current medical imaging. Since their invention in 1895, radiographs have been used to identify and diagnose abnormalities so that treatments can be given. The increased use of radiographs has improved lives through early detection of conditions leading to further studies and/or treatments of identified diseases. Radiology science has led to the development of more precise testing modalities such as CT, MRI, nuclear medicine, and ultrasonography.

Radiographs can be either plain, meaning there is no contrast enhancement, or they can be a contrasted study (Figure 2.1). Plain radiographs are ideal for identifying gross abnormalities and foreign bodies, visualizing calculi and fractures, or evaluating air fluid and gas patterns. They are
advantageous because they are inexpensive, nonoperator dependent, and readily available as they can be obtained in a designated radiology room, using a portable machine, or in a mobile unit such as a mobile mammography bus. One of the disadvantages of radiography is its limited ability to contrast densities of organs and tissue.

Radiographs are performed utilizing a single view. This means that the x-rays are emitted from the cathode tube and directed toward a cassette on the other side of the patient. The direction of the beam penetrating the patient is how that particular view is labeled. When we have a posterior–anterior (PA) view, the tube is behind the patient (or posterior, hence “P”) who is standing or sitting erect with the cassette directly in front of him or her. The x-ray beam then travels from the tube, penetrating from the back to the front (or anterior, hence “A”) of the patient. The image is then produced on the cassette in front of the patient (Figure 2.2A). In the anterior–posterior (AP) view, the opposite occurs (Figure 2.2B). The image is also labeled based on the position of the patient, such as erect, supine, prone, or decubitus. In the lateral decubitus view, the patient lies on his or her side for at least 3 to 5 minutes to allow any free air to rise and is then imaged in a side-lying position (Figure 2.2C).
FIGURE 2.2 Normal chest posterior-anterior view (A); normal chest lateral view (B); and decubitus view (C). Note the air/fluid levels on the decubitus view.
(A) and (B) courtesy of Theresa M. Campo; (c) courtesy of Dr. Keith Lafferty.
Contrast can be used to highlight areas of interest such as the intestines, bladder, kidneys, vessels, and so on. Contrasted studies can be static or dynamic. Static images are stationary images in a one-plain view. Dynamic images give real-time radiographic visualization of moving anatomical structures such as the heart and diaphragm. These are performed using fluoroscopy, which can be either diagnostic or therapeutic. Therapeutic uses can include cardiac catheterization with stent placements, injections into the spinal canal, or vascular line placements.

Fluoroscopy involves a fluoroscopic screen combined with an electronic device that converts visible light into an electron score stream. This technique amplifies the image, making it brighter, and then converts it back into visible light. When fluoroscopy is performed, the x-ray tube lies beneath the table. With the tube beneath the table, the cassette is then supported over the top of the table and the patient is positioned for the particular study or therapeutic intervention (Figure 2.3). The study may be labeled on the basis of the patient’s position relative to the tube. For example, a right posterior oblique indicates the patient lying with his or her right side down, back against the table, at an angle greater than 0° and less than 90° with the tube beneath and the cassette overhead.

Radiographs have revolutionized medicine since their discovery in 1895, leading to new testing modalities such as the CT scan, nuclear scan, MRI, and ultrasonography. With the utilization of plain and contrasted radiographs, patients are being diagnosed earlier with abnormalities and disorders that can now be treated earlier and more definitively. Technological advances will surely lead to more enhanced testing modalities and better and safer testing modalities in the future.
There are many benefits to radiographs such as cost, ease of ordering, and ease of interpretation, as well as utilization of contrasted studies. However, the clarity and definition gained through other radiologic testing such as CT and MRI have led to a decreased use of contrasted radiographs, for example, barium enema. Radiographs are limited by single views and limited contrasting of structures that are overcome with the use of cross-sectional imaging of the body with CT, MRI, and ultrasonography, which will be discussed in this chapter and Chapter 3.

COMPUTED TOMOGRAPHY (CT)

Computed tomography (CT), also known as computed axial tomography (CAT) scanning, was first introduced by Sir Godfrey Hounsfield and Dr. Allan Cormack around 1974. Radiographs produce only one image of one two-dimensional plain from one beam. However, CT scans can produce multiple slices, allowing for reproducible images in three-dimensional plains.

CT scanners employ an x-ray beam that rotates along a circular pattern with detectors rotating along the opposite side. This allows for the system to move in a 360° circle with a well collimated or restricted beam. The beam only travels in one direction through the patient to the detector on the opposite side (Figure 2.4). A complex computer system utilizes algorithms and mathematical formulas to process the data into a large number of two-dimensional slices, like images that can then be formatted into multiple reconstructed plains. The data analyzed by the computer system then assign Hounsfield units (HU) to reconstruct the image based on geometrical plots.

FIGURE 2.4 CT scanner showing 360° of circle detectors and beams.
Drawing by Ocean City High School student.
Images are composed of a matrix of thousands of tiny squares called pixels. The pixels have a computer-assigned number that correlates to an HU. As discussed earlier, this scale is what produces the shades of gray from black to white. HUs are not absolute and may vary from one CT system to another. HU range from -1,000 to +1,000. However, they can also range from -1,024 to +3,000 or 4,000.

During a CT scan, the patient is placed on a table and the x-ray beam and detector system move through the 360° around them. The detectors receive the x-rays and measure the amount of absorption of the rays as they pass through the body. This data is obtained by the computer and then analyzed and assigned a HU. The computer then produces an image based on the geometric plots of pixels (which are based on the absorption and scatter of the x-ray), resulting in an image on the screen. When viewing the results, the appearance of the images is dependent on the window and level used to display the image. The window describes the range of HUs displayed, and the level describes the center of the window. The wider (or larger) the window, the more types of densities that will be displayed; however, the difference between similar types of tissue lessens, making tissue differentiation difficult to discriminate. The level and window is displayed on every CT image.

The CT image is made up of multiple individual boxes, called pixels. The CT pixel number is proportional to the differences in attenuation of the x-ray by the tissue and is compared with water. The number of pixels can be changed, but they are typically in a matrix (such as 256 × 256). Each image will also have a slice thickness, and the two-dimensional slice will represent all the densities within the volume. The volume of tissue represented by the pixel is called a voxel. The forecastle allows for reconstruction of images by the computer system without losing resolution of the image. Voxel dimensions are determined by the computer system utilizing algorithms that are chosen for the type of reconstruction and are based on the thickness of the scanned slices. If a particular tissue, organ, or lesion is of increased density, then there will be increased absorption, resulting in increased attenuation of the x-ray beam. The more a substance attenuates the beam, the more radiopaque or radiodense it is said to be. On the black and white scale of images on a CT, typically the more radiodense an object is, the closer to white it is displayed. If the particular objects are of decreased density, then there will be decreased absorption of the ray or decreased attenuation, causing a black appearance on the image that is known as radiolucency. You may hear of objects described this way, with a radiodense objection being called a “high density” object (such as a stone or calcification) or “low density” object (such as gas or fat).

The axial view is the traditional view obtained by the computed axial tomography scanner. With the ability to reconstruct images, the computer system can include sagittal, coronal, and oblique plains (Figure 2.5). CT computer systems also utilize volumetric data to produce a three-dimensional image during the reconstruction process (Figure 2.6). This is due to the
ability to produce volumetric data sets. Three-dimensional reconstruction is because of the higher speed scanning of multislice CT and increased computer processing speed and ability.

Conventional single slice scanners were much slower than the technology utilized today with helical or spiral scanners. This is because the patient would hold his or her breath while a single slice was taken and then release his or her breath. The table would then move and this would be repeated. This produced images in slices or sections.

Currently, helical or spiral scanners are utilized to acquire images. These systems allow the table to move at a constant speed, which allows for a more rapid study. Modern systems also include multidetectors, allowing for data to be acquired using rows of detectors that rotate at one time. Multidetector and multislice systems and technology allow for additional
An advantage of current CT scanners is their ability for rapid scan acquisition. This rapid scanning allows for larger areas to be scanned in less time with greater resolution. That means that breathing and motion artifacts are greatly reduced; there is greater resolution of images, allowing smaller and smaller objects to be visualized and even allowing scanning of certain areas, such as the coronary arteries, which were never before possible. They also allow for accurate multiplanar and three-dimensional reconstruction (this is true of any CT, single or multislice).

CT fluoroscopy can be used with current CT scanners (another advantage of multislice CT). Fluoroscopy improves the performance of image-guided procedures such as biopsies, drainage, and other interventional procedures and is of particular use in guiding needle placement in the chest and abdomen areas that are prone to movement. These CT scans may also be enhanced with the use of contrast, either intravenous, oral, or rectal. Oral and rectal routes are beneficial in visualizing and identifying the bowel and its abnormalities. Intravenous contrast is helpful in enhancing vascular anatomy, vessel patency, and identification of lesions or masses and improves the ability to characterize them. Enhancement assists in differentiating normal anatomy from pathology.

As with radiographs, CT images can be affected by many factors. Artifact has the greatest impact on the clarity of an image. There are many types of artifacts that can affect image quality. If a patient voluntarily or involuntarily moves during the study, it can affect the image, causing prominent streaks from higher to lower density that appear as blurring or shadowing of structures. Metal objects such as surgical clips, staples, and dental fillings can cause streak artifacts because the computer systems are not able to distinguish between high-density sharp-edged objects and adjoining lower density structures. Beam hardening artifacts may be seen as areas of streaking on images, whereas ring artifacts can demonstrate high- or low-density circular rings on the image (Figure 2.7).
FIGURE 2.7 (A) through (D) demonstrate positron (positive electron) emission tomography scan images. Courtesy of Dr. David Begleiter.

CT scans are extremely beneficial in diagnosing critical abnormalities and producing real-time images. This allows for CT-guided procedures and fluoroscopy because of the rapid obtaining of images with multislice and
multidetector scanners. With the advancements in technology, computer systems allow providers to view areas of interest in multiple plains, including three-dimensional images.

NUCLEAR SCANNING

Nuclear medicine scans and their images are both diagnostic and therapeutic. Nuclear imaging for diagnostic purposes involves a radioactive isotope, an unstable form of an element that emits radiation from its nucleus as it decays, resulting in a stable, but nonradioactive product. Radioactive isotopes occur naturally and artificially. Uranium and thorium are examples of naturally occurring radioactive isotopes. Artificial radioactive isotopes can occur through either neutron enrichment in a nuclear reactor or within a cyclotron. Radioactive isotopes are low dose, nontoxic, and have a short half-life. They are readily incorporated into physiologic compounds and are relatively inexpensive. Technetium 99 m is the most widely used radioisotope in imaging studies.

Radioisotopes are combined and attached to inert agents with binding properties, allowing for concentration in body tissues. Various tissues and organs absorb substances differently. For example, the thyroid best absorbs iodine, the brain best absorbs glucose, and bones best absorb phosphate. Radiopharmaceuticals are referred to as radionuclides, radio tracers, or simply tracers. Most are carried to tissues or organs by the bloodstream; the gamma camera imaging is used to measure radioactive emission. Some agents may be given orally or inhaled, as in ventilation/perfusion (V/Q) scans, or instilled in the bladder for reflux studies. In its simplest form, the gamma camera records radiation emissions from a patient in a single view or plain at point; in its more advanced form, the gamma camera rotates around the patient, acquiring several two-dimensional images from multiple angles. The two-dimensional images are then reconstructed into a three-dimensional data set by a computer. This is known as single-photon emission computed tomography (SPECT).

Positron (positive electron) emission tomography (PET) produces a three-dimensional image depicting the body’s biochemistry and metabolic processes at a molecular level. The positive electron or positron radioisotope is attached to a pharmaceutical used in the body’s metabolism. This radiopharmaceutical is taken up proportionally with how metabolically active the tissue is. This technique is useful in diagnosing cancer; it is also useful following changes resulting from therapeutic interventions, creating the ability to identify hidden metastasis and recurrence. The PET cyclotron, or generator, produces isotopes with a relatively short half-life that emit positrons. Positrons are significantly higher energy particles that are recorded and used to produce PET images. In general, positron emission generates far less radiation exposure than CT scans or fluoroscopy. However, cardiac PET scanning is known to
generate the greatest amount of radiation exposure among all nuclear studies. Figure 2.8 shows examples of PET scan images.

As stated earlier, the half-life is generally shorter with radioisotopes than with other agents. Generally, there are three ways to describe the half-life of a radioisotope. The physical half-life is the period in which an element would decay naturally on its own whether it is sitting on the shelf in a container or if it has been administered; that is, the time at which half of the original radioactivity is gone. The biologic half-life is based on the normal physiologic removal of the radioisotope and the pharmaceutical. For example, when it is excreted from the kidneys and/or the gastrointestinal tract, the biologic half-life is shorter than the natural physical half-life. Finally, effective half-life is a mathematical derivation based on formulas that combine biologic and physical parameters. It is a measurement of when the actual isotope remains effective within the body.

PET scanning can be used in conjunction with a CT scan to give a more accurate localization of an abnormality or lesion for surgery or biopsy, or to identify suspected metastasis. When PET and SPECT CT scanning are performed together, there is an increased specificity and sensitivity in
the cardiac, neural, and oncological identification of abnormalities. These enhanced imaging modalities also improve the identification of malignancies and staging of treatment in cancer patients.

Nuclear imaging is unique in its ability to provide high functional resolution, providing physiologic as well as functional information of organ structure that is not otherwise available with CT, MRI, or ultrasound imaging. Functional imaging identifies whether an organ is normally or abnormally functioning, independent from anatomical abnormalities.

Two types of images can be obtained with a nuclear study: static or dynamic. Static images evaluate organs and areas in a still state, such as thyroid scans, liver scans, splenic scans, and so on (Figure 2.9). Dynamic images include rapid sequence images of moving areas such as blood flow to organs, muscles of the skeleton, and renal perfusion. Nuclear imaging is based on the detection and mapping of the biodistribution of radio tracers that have been administered and captured by emission imaging. Table 2.1 demonstrates the five

TABLE 2.1 The Five Basic Isotope Concentrations in the Body

<table>
<thead>
<tr>
<th>Type of Isotope Concentration</th>
<th>Scan</th>
<th>Absorption</th>
<th>Evaluates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blood pool or compartment localization</td>
<td>Cardiac</td>
<td>Glucose</td>
<td>Perfusion</td>
</tr>
<tr>
<td></td>
<td>Brain</td>
<td></td>
<td>Function</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Viability</td>
</tr>
<tr>
<td>Physiological inclusion</td>
<td>Thyroid</td>
<td>Iodine</td>
<td>Goiter</td>
</tr>
<tr>
<td></td>
<td>Bone</td>
<td>Phosphates</td>
<td>Hyperthyroid</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Cancer</td>
</tr>
<tr>
<td>Capillary blockage</td>
<td>Lung</td>
<td></td>
<td>Metastasis</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pulmonary embolus (obstruction)</td>
<td>Abuse</td>
</tr>
<tr>
<td>Phagocytosis</td>
<td>Liver</td>
<td></td>
<td>Cholestasis</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Quantitative perfusion</td>
<td>Mass</td>
</tr>
<tr>
<td>Cell sequestration</td>
<td>Spleen</td>
<td></td>
<td>Injury</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mass</td>
</tr>
</tbody>
</table>
FIGURE 2.9 Dynamic image; pre-exercise nuclear stress test (A); large antero apical and septal ischemia (B). Note loss of areas in all three views compared to a normal scan. Courtesy of Dr. Yatish B. Merchant.
basic isotope concentrations in the body, the mechanism, the type of study, what is assessed in that study, and what is absorbed by that particular organ with consideration of radioisotopes attaching to pharmaceuticals.

Nuclear imaging allows for identification of abnormal tissue, such as cancer and metastasis, and provides imaging, reflecting the functionality of an organ and/or system. Innovations in the field of nuclear imaging include molecular medicine and molecular imaging, applying genomics and protein messaging that allows the following of gene therapy as well as stem cell therapy from its introduction into the patient. The capabilities of nuclear imaging allow the diagnosis of abnormalities and can measure therapeutic effects so interventions can be modified based on the patient’s response.

CONCLUSION

The three radiating testing modalities are similar in the foundation of how the image is obtained. However, CT and nuclear imaging take this foundation further with multiple views, contrast, and digital technology. When deciding on the appropriate testing modality to order, it is important to take into consideration how the images are obtained and what you are looking to achieve.

Consideration must be taken into account for the amount of radiation exposure a patient receives from every radiological study. The risk and benefit as well as the necessity of each study must be weighed carefully to protect patients. A radiation dose of 50 millisieverts (mSv) can place a person at risk for cancer. A CT of the abdomen and pelvis can emit approximately 30 mSv when performed with and without contrast. Correlation of cancer to radiation exposure can take one to two decades, making it difficult to determine the actual risk.

RESOURCES


Basic Interpretation of Long Bone—Upper Extremity Radiographs

Radiographs of long bones, whether of the upper extremity or the lower extremity, are usually performed after a traumatic injury. However, pain, swelling, and/or redness may also be an indication for obtaining radiographs to rule out an abnormal growth, bursitis, and foreign bodies. Plain radiographs of long bones are beneficial in identifying fractures, subluxation, dislocation, and soft tissue swelling in traumatic injuries and are also useful in evaluating nontraumatic signs and symptoms such as abnormal bone growths.

In this chapter, normal findings on plain radiographs are discussed along with joint structures and normal variants, as well as common findings in adults and children. Knowledge of normal anatomical structures is imperative in interpreting long-bone radiographs.

NORMAL

Before ordering a plain radiograph of a long bone or joint, it is important to review some of the rules discussed in earlier chapters. Additionally, when evaluating the upper extremity, it is important to not only evaluate the affected area, but also the joints above and below. For instance, if the patient complains of an injury to the forearm, medical imaging should include the elbow as well.
as the wrist. Routine studies should include a minimum of two views; most have three views or more, depending on the area in question.

Plain radiographs are excellent in identifying bony abnormalities such as fractures. Although not the best modality for evaluating soft tissue conditions surrounding a particular joint, such as cartilage, muscle, and tendons, which are best seen using MRI, plain films do show changes within joint alignment and edema, which are indicative of an occult bone fracture, trauma, or inflammation. An example of an occult fracture finding is when the posterior fat pad, which is only visible if bleeding occurs within the joint space, is viewed on the lateral view of an elbow and the anterior fat pad appears like the sail of a sailboat, which is suggestive of a radial head fracture that may not be seen in the bony cortex (Figure 7.1).

![Anterior Sail Sign “Fat Pad”](image)

![Posterior Fat Pad](image)

**FIGURE 7.1** Anterior and posterior (A) and lateral (B) fat pad sign elbow. Courtesy of Dr. Douglas W. Parrillo; diagramming, Theresa M. Campo.

The upper extremity consists of the shoulder, elbow, wrist, and phalangeal joints and associated bones: humerus, radius, ulna, carpal, metacarpal, and phalanges. Each joint and each bone have different appearances as well as functions within the upper extremity. Abnormalities can cause inhibition of normal function and use of the upper extremity. There are five types of bones in the body, as shown in Table 7.1. When evaluating bones on a radiograph, scan the cortical margins and note alignment to identify an abnormality.

**TABLE 7.1** Five Types of Bones, Definition, and Examples

<table>
<thead>
<tr>
<th>Type of Bone</th>
<th>Definition</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long bone</td>
<td>The length is greater than the width</td>
<td>Femur, humerus, phalanges</td>
</tr>
<tr>
<td>Short bone</td>
<td>The length and width are comparable</td>
<td>Cuboid bones, carpals, tarsals</td>
</tr>
</tbody>
</table>

(continued)
The ABCs of interpretation can be utilized for systematic assessment of the upper extremity. A is for adequacy and alignment. As stated in previous chapters, adequacy of the film is of the utmost importance when evaluating any radiographs. Proper alignment allows the viewer to identify subtle joint abnormalities. It does not only refer to the alignment of one particular bone, but also alignment within the joint (see Figure 7.2A). B is for bones and refers to the evaluation of all components of the bone in the respective study. Cortical margins and borders should be evaluated for any disruption or lack of continuity of that bone indicative of a fracture. It also refers to any abnormal growths or appearances, which may appear as densities or opacities on the radiographic image (see Figure 7.2B). Cartilage and joints can be evaluated for abnormalities with visualization of the joint space. Loss of any joint space may be indicative of a crush injury or could be a sign of degenerative joint disease. Bulging or displacement of normal structures in the lower extremity may be indicative of a joint effusion (see Figure 7.2C). Soft tissue can give signs of trauma with the joint effusion or edema. It can also assist the provider in identifying radiopaque foreign bodies that may have occurred during the injury itself.
ABNORMALITIES OF THE UPPER EXTREMITY

Fractures

*Describing Fractures*

A fracture or break to a bone, or bones, can happen from injury or pathology. Simply describing a fracture is important when documenting findings, but it is also important to utilize the proper terminology when describing these findings. A fracture line or pattern may be transverse, oblique, spiral, comminuted, impacted, avulsed, compressed, or depressed. A fracture may only involve one side of the bone, may involve both sides, or may go completely through the bone itself (see Figure 7.3). A normal variant that may be visualized involves blood vessels along the bone appearing as fractures. These can be differentiated from a fracture by tracing the lines and seeing if they pass the normal border of the bone (cortex). However, it is important to note that both may go through the cortex; many vascular channels traverse the cortex and make differentiating difficult.

![Fracture patterns](image)

**FIGURE 7.3** Fracture patterns.
Drawing by Ocean City High School student.

Fractures may involve one bone or multiple bones. There may also be multiple fractures within the same bone but in different areas. The bone fragments may be displaced or nondisplaced. When a bone fragment is 100% displaced, causing shortening and overlapping of the bone fragments, this is known as a bayonet deformity (Figure 7.4). When the bone fragments are out of alignment of each other, they are considered to be angulated. Angulation is the angle between the longitudinal axis of the main fracture fragment and the other fragment. Significant angulation requires reduction and realignment of the bone fragments. If the fracture line is forced into the joint space, it is considered to be an intra-articular fracture (Figure 7.5).

A stress fracture can occur with repetitious loading beyond the bone tolerance. An avulsion fracture may occur when there is a forcible muscular
contraction of tendinous (tendon attaches muscle to bone, whereas ligament attaches bone to bone) attachment to a bone that is pulled off and away from the main structure.

**Pediatric Considerations**
Special consideration needs to be given with the pediatric patient. Pediatric bones are more fibrous and less crystalline (or calcified) than adult bones. They are enclosed in a sheet of strong fibrous periosteum and have epiphyseal growth plates, which are a zone of weakness. Children tend to have incomplete fractures such as a greenstick fracture or torus fracture because the bone
ends do not separate as in adults because of the strong periosteal sleeve. The most common types of fractures in the pediatric patient are elastic deformation, bowing deformation, torus or buckle fracture, greenstick fracture, Salter-Harris fracture, stress injury, and avulsion injury (Figure 7.6).

Pediatric bones have epiphyseal growth plates that allow the bones to grow until they are mature adult bones. When a fracture occurs within or around the growth plate, it can complicate the healing process. Gross disturbances can be expected and the potential for loss of growth of the long bones may occur. However, current literature demonstrates that the loss of length after a fracture of a long bone tends to be made up in 1 to 2 years after the injury by overgrowth. The epiphyseal growth plate is a zone of weakness that can make fracture, separation, and slipping of the growth plate more common in the pediatric patient.

The Salter–Harris classification system is used to describe the five different types of pediatric growth plate fractures based on abnormalities involving either the metaphysis, epiphysis, and/or diaphysis. A Salter I fracture is a separation of the growth plate without involvement of the metaphysis or the epiphysis. A Salter II fracture occurs across the growth plate but with a small fragment of metaphysis remaining attached to the epiphysis. A fracture

![Figure 7.6 Pediatric fractures.](image-url)

Drawing by Ocean City High School student.
across the growth plate with extension of the fracture line across the epiphysis is known as a Salter III fracture. When the fracture line traverses the epiphysis and part of the diaphysis, this is known as a Salter IV fracture. Finally, when there is damage to both the epiphysis and the metaphysis from a crush injury this is known as a Salter V fracture. As you will notice, the severity of the injury, increases with the designating number of the Salter–Harris fracture (see Figure 7.7). An easy mnemonic to remember the Salter classification is SALTR. s refers to a slip as in a Salter I, a refers to the fracture noted above or proximal to the epiphyseal plate, l refers to a fracture below or distal to the epiphyseal plate, t is a fracture line extending through the epiphyseal plate including both the epiphysis and metaphysis, and r refers to crush.

**FIGURE 7.7** Five types of Salter–Harris fractures. Drawing by Ocean City High School student.

**Shoulder**

Alignment of the glenohumeral joint should demonstrate the humeral head lying in the glenoid fossa, and the distance between the humeral head in the anterior margin of the glenoid should be equal from top to bottom (Figure 7.8). If the humeral head is internally rotated and looks like a light bulb, on a plain radiograph, suspect a posterior dislocation. Alignment of the acromioclavicular joint should show alignment of the inferior margins of the lateral end of the clavicle and acromion.

The shoulder is made up of three bones: the clavicle, the humerus, and the scapula. The scapula provides support and stability to the shoulder through three structures where tendons and ligaments attach. The coracoid process is in the anterior plane of the shoulder blade and the acromium is in the posterior region. These structures are supported by the coracoclavicular ligament. The humeral head is adjacent to the glenoid portion of the scapula and is supported by the muscles, tendons, and ligaments that make up the rotator cuff. This region is referred to as the glenohumeral joint. The distal aspect of the clavicle, adjacent to the acromium, comprises the acromioclavicular joint. A fracture of any of the bony structures within the shoulder or a soft tissue injury to the rotator cuff ligaments and/or tendons results in shoulder instability, loss of function, and pain (see Figure 7.8).
Shoulder injuries are common in all age groups and may consist of a fracture, dislocation, or both occurring simultaneously. Clavicular fractures are the most common fractures in children and adolescents. Shoulder dislocation and acromioclavicular (AC) separations are most common in adults. In the elderly, the most common injury is fracture of the humerus, particularly the head and neck. If soft tissue injury is suspected and a dislocation and/or fracture has been ruled in or out with plain radiographs, an MRI should be considered for better visualization of the soft tissue structures.

Radiographic studies of the shoulder should have three views: the anterior–posterior (AP) view, axial view, and the “Y” view (Figure 7.9). The AP view allows for viewing the contour of each bone, which should be evaluated systematically. One should note that the cortices are smooth and visible ribs should also be evaluated. In the axial view, identification of
the coracoid process should be visualized. The axial view is also useful in 
assessing the glenohumeral alignment for evaluation of any avulsions of the 
glenoid rim and for a Hill-Sachs defect of the humeral head. The “Y” view 
is beneficial for confirming normal alignment of the glenohumeral joint and 
identification of either an anterior or posterior dislocation.

As children grow and develop, so do their bones. There is formation of 
ossification centers of the humerus, scapula, and clavicle, which are formed 
over years and eventually fuse. Table 7.2 demonstrates the time of formation and time of fusion of the secondary ossification centers.

TABLE 7.2 Ossification Center Formation and Fusion

<table>
<thead>
<tr>
<th>Shoulder Bone Ossification Center</th>
<th>Formation (years of age)</th>
<th>Fusion (years of age)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Humeral Head</td>
<td>&lt; 6 months</td>
<td>16–18</td>
</tr>
<tr>
<td>Humerus - Greater Tuberosity</td>
<td>1</td>
<td>4–6</td>
</tr>
<tr>
<td>Humerus - Lesser Tuberosity</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Scapula - Coracoid</td>
<td>1</td>
<td>20</td>
</tr>
<tr>
<td>Scapula - Inferior Angle</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Scapula - Acromion</td>
<td>15</td>
<td>20–25</td>
</tr>
<tr>
<td>Clavicle - Medial Margin</td>
<td>18</td>
<td>25</td>
</tr>
</tbody>
</table>
Clavicle

Clavicle fractures can occur from minimal force and most often occur in the midshaft and distal aspect (Figure 7.10). Midshaft clavicle fractures may be seen more frequently in younger individuals, especially those younger than 20 or 21 years of age. Fractures of the lateral/distal aspects are more common in older individuals. The skin overlying a clavicle fracture should be assessed for tenting that is causing skin displacement. Tenting can result when fracture fragments protrude and pinch the skin. These fracture fragments may need to be repaired, requiring surgical intervention. One should suspect an intrathoracic injury with any proximal clavicle fracture, such as pneumothorax or pneumomediastinum.

![Clavicle Radiographs](A,B,C)

**FIGURE 7.10** Normal clavicle (A and B) and distal clavicle fracture (C). Courtesy of Dr. David Begleiter.
Scapula
Fractures to the scapula incur a great deal of direct force and have a high correlation of injury to the thorax, head, and spine. When evaluating or identifying a scapular fracture, it is imperative that the provider completely evaluate all of the surrounding structures for accompanying injury. Scapular fractures can be difficult to identify and visualize on a plain radiograph. Obtaining a “Y” view is most beneficial, but MRI or CT scanning may be necessary for a definitive diagnosis (Figure 7.11).

![Scapula fractures. Note in (A) and (B) the comminuted fracture with multiple bone fragments. (C) demonstrates the importance of more than one view for visualization of the fracture. Courtesy of Dr. David Begleiter.](image)
**Humerus**

There are four parts to the proximal humerus: the greater tuberosity, lesser tuberosity, head, and neck leading to the shaft (Figure 7.12). Proximal humeral fractures have a peak incidence during adolescence, causing epiphyseal separation. Fracture of this region in adults aged 45 years and older is most often due to osteoporosis. A fall with an outstretched hand is one of the more common mechanisms for fracture of the proximal humerus. If a fracture occurs in the humeral neck, it may be accompanied by complications from neurovascular injury, avascular necrosis, and adhesive capsulitis. A compression fracture of the posterolateral humeral head is known as a Hill–Sachs fracture and may be caused by anterior glenohumeral dislocation and impaction of the humeral head against the anterior glenoid rim.

Fractures to the shaft of the humerus may be complicated by injury to the radial nerve with entrapment or impingement. When a fracture occurs in the distal third of the humerus involving radial nerve entrapment, this is known as a Holstein–Lewis fracture (see Figure 7.13).

![Figure 7.12](image_url) Four parts of the proximal humerus. Greater tuberosity (A); humeral head (B); lesser tuberosity (C); and humeral neck going into the shaft (D). Courtesy of Dr. David Begleiter.
FIGURE 7.13 (A) through (D) demonstrate humerus fractures. Courtesy of Dr. David Begleiter and Theresa M. Campo.
Elbow

The elbow joint consists of the distal humerus and the proximal radius and ulna. The distal humerus consists of the medial and lateral epicondyle, coronoid fossa, capitellum, and trochlea (Figure 7.14). The radial head, radial tuberosity, ulnar tuberosity, and olecranon process are key areas when evaluating an elbow image. The ulna and olecranon process articulate with the trochlea and the olecranon fossa of the humerus. The radial head articulates with the capitellum and the two structures should be aligned in all projections. Trauma to the elbow occurs in all ages but most commonly in children. Elbow fractures in children require emergent orthopedic consultation to avoid permanent deformity and loss of function. It is important to obtain an AP, lateral, and two oblique views when imaging the elbow.

FIGURE 7.14 Three views of a normal elbow study.
Courtesy of Dr. David Begleiter.
As with the shoulder, the pediatric patient has ossification centers in the elbow joint that appear and fuse at different ages. It is important to know the sequence of the appearance as well as fusion of these ossification centers in order to identify normal from abnormal findings. The order of appearance can be easily remembered with the mnemonic CRITOE, which represents capitellum, radius, internal or medial epicondyle, trochlea, olecranon, and external or lateral epicondyle (Figure 7.15). The ages that these ossification centers appear are highly variable and differ between individuals; however, a general guide or rule of thumb is to remember the following:

- C = 1 year
- R = 3 years
- I = 5 years
- T = 7 years
- O = 9 years
- E = 11 years

![Figure 7.15 Elbow ossification centers (CRITOE). Anterior–posterior view equivalent (A) and lateral view equivalent (B). Drawings by Theresa M. Campo.](image)

Evaluating alignment in the pediatric patient is also important because of the epiphyseal growth plates. The radiocapitellar line is a line drawn through the long axis of the radius that should always point toward the center of the capitellum regardless of the position of the patient since the radius articulates with the capitellum (Figure 7.16). When a dislocation occurs of the radius, the line will not pass through the center of the capitellum. An anterior humeral line is a line that can be drawn on a lateral view along...
the anterior surface of the humerus and should pass through the middle third of the capitellum (Figure 7.16). With a supracondylar fracture, the anterior humeral line will pass through the anterior third of the capitellum or directly in front of the capitellum due to posterior bending of the distal humeral fragment.

Fractures to the distal humerus can involve either the medial condyle or lateral condyle and can be very severe. Fracture of either one or both epicondyles can lead to long-term complications and disability of elbow movement. Fractures can occur anywhere within or above the condyles. Vascular and nerve injuries can occur with significantly displaced condylar fractures due to the brachial artery and median nerve, both lying anteriorly. Supracondylar fractures occurring in children are most commonly caused by a fall on outstretched hand (FOOSH) injury. Table 7.3 provides a description of various condylar fractures.
Radial head fractures most commonly occur from a FOOSH injury in adults. Occult fractures of the radial head may only be identified by visualization of fat pads. It can be normal to see a very small anterior fat pad located anterior to the coracoid. However, when the anterior fat pad is pushed outward and resembles the sail of a sailboat (known as a sail sign) and/or a posterior fat pad is easily visible, it is due to an effusion caused by leakage of blood from the bone and marrow into the joint. If these occur, an occult fracture must be considered and ruled out with further imaging (Figure 7.17).

![FIGURE 7.17](A), (B), (C), and (D) demonstrate a condylar fracture of the humerus with an anterior sail sign and posterior fat pad. Courtesy of Dr. Douglas W. Parrillo; diagramming, Theresa M. Campo.

(continued)
Radius and Ulna

A distal radial fracture may occur solely or may be associated with dislocation of the distal radioulnar joint. This is commonly known as an Essex–Lopresti fracture (Figure 7.18). If the proximal third of the ulna is fractured with an associated dislocation of the radial head, this is known as a Monteggia fracture (Figure 7.19). The radius and ulna may be fractured anywhere along the shaft of one or both of these bones. Injury may result from either a direct blow to the posterior ulna or a fall with forceful pronation of the forearm. Radial head displacement into the antecubital fossa, elbow pain, and tenderness may be seen on clinical evaluation.

![Image of Essex–Lopresti fracture](image)

**FIGURE 7.18 (A), (B), (C), and (D) demonstrate Essex–Lopresti fracture.**
FIGURE 7.19 Monteggia fracture.
Available at http://emedicine.medscape.com/article/1231438-overview
A Galeazzi fracture occurs when the proximal radius is fractured and associated with either subluxation or dislocation of the distal ulna (Figure 7.20). Barton’s fracture occurs when there is displacement of the articular lip of the distal radius that may be associated with a carpal subluxation. A chauffeur’s fracture, also known as a Hutchinson fracture, occurs when there is an intra-articular fracture of the radial styloid; this was named during the era of crank automobiles (Figure 7.21). A Colles fracture is when the fracture fragment of the distal radius is dorsally displaced with volar apex angulation (Figure 7.22). This fracture most often occurs from a FOOSH injury in elderly women. Approximately 50% of Colles fractures occur with an associated ulnar styloid fracture. When there is a distal radial fracture with volar displacement it is known as a Smith fracture.

FIGURE 7.20 Galeazzi fracture.
Courtesy of Hellerhoff/Wikipedia Commons.
FIGURE 7.21 (A) and (B) demonstrate chauffeur’s fracture.

Copyright 2016. Dr. Alexandra Stanislavsky. Image courtesy of Dr. Alexandra Stanislavsky and Radiopaedia.org. Used under license.
Long-bone fractures in children that do not penetrate or break through the bony cortex are referred to as greenstick fractures. There are three types of greenstick fractures: transverse fractures occurring only half way through the bone; torus or buckle fractures where the cortex of the bone buckles and becomes overlapping; and bowing-bent bone when there is no identifiable bony cortex disruption but bowing of the bone is visualized (Figure 7.23).
Carpals
Fractures may occur to any of the carpal bones; however, they are less frequently seen in comparison with metacarpal fractures and distal radius and ulna fractures. Carpal injuries are more commonly associated with separation and dislocation; in addition, fractures to the metacarpals and phalanges occur more frequently than fractures and dislocations of the carpal bones.

A triquetral fracture is the second most common carpal fracture, with scaphoid fracture being the most common. In this type of fracture, there is bone avulsion from the dorsal surface that is best viewed in the lateral view of the hand. Noting any soft tissue abnormalities of the dorsal wrist can also aid in identification of this fracture (Figure 7.24).
Scaphoid fractures, the most common carpal fractures, can be difficult to identify on radiographs (Figure 7.25). Obtaining a scaphoid view of the wrist may aid in identification along with assessing for tenderness in the anatomical snuff box region of the hand. This injury occurs with extreme dorsiflexion of the wrist and ulnar deviation. This type of fracture rarely occurs in children.

![Image of scaphoid fractures](image-url)

**FIGURE 7.25** (A) through (C) demonstrate a scaphoid fracture. Courtesy of Dr. Douglas W. Parrillo.

**Metacarpals**

One of the more common fractures of the hand is a boxer’s fracture. This occurs during a punch-type injury or close-fisted impact, causing a fracture to the fifth metacarpal neck with volar displacement of the head of the metacarpal. Boxer’s fractures may also involve the fourth metacarpal (Figure 7.26). These can become problematic injuries if there is open skin caused by a punch to another person’s mouth with bacterial contamination from saliva. It is imperative that any punch injury with a bite and contamination from saliva or mucus be treated as an open fracture with antibiotic prophylaxis combined with close monitoring and orthopedic follow-up.
FIGURE 7.26 (A) through (C) demonstrate a Boxer’s fracture.
Copyright 2016 Dr Henry Knipe. Image courtesy of Dr. Henry Knipe and Radiopaedia.org. Used under license.
A Bennett’s fracture is an intra-articular fracture—dislocation of the base of the first metacarpal. The separating triangular fragment most commonly dislocates dorsally (Figure 7.27). This type of fracture occurs from axial loading and most commonly occurs from a fight injury. Transverse or oblique are other common metacarpal fractures that may involve one or multiple metacarpals.

**Phalanges**

Fractures to the phalanges can be caused by crush injuries, jamming of the finger or fingers, or from direct trauma. Fractures to the distal phalanx need to be evaluated for possible nail plate and/or nail bed injury. Comminuted fractures of the tuft of the distal phalanx from a crushing injury may result in partial or full amputation of the distal finger (Figure 7.28).

**Dislocations/Subluxations/Separations**

Articular surfaces of bones within joints are kept in place by ligaments and cartilage. When the alignment of the adjacent bones is not maintained or they have lost complete contact with each other, then a subluxation or dislocation occurs. With a subluxation, the articular surface of one
FIGURE 7.28 Phalange fracture. Fracture at the base of the fifth proximal phalanx (A); fracture to the middle phalanx (B and C); midshaft fracture of fifth proximal phalanx (D). Note the appliance to the third proximal phalanx.

Courtesy of Kyle Deuter.
bone maintains contact with the articular surface of the adjacent bone. Although the bones are not in complete alignment, they have not lost contact with each other. When a dislocation occurs, the articular surface of one bone loses complete contact with the other, causing a complete disarticulation.

**Shoulder**

Dislocations occurring in the shoulder are most commonly either anterior, posterior, or inferior. For the purposes of this book, we will only discuss anterior and posterior dislocations, as inferior dislocations are less common. Anterior dislocations are most common, with posterior dislocation occurring in approximately 3% of all cases. Shoulder dislocations are the most commonly occurring due to the incredible range of motion and the anatomical structures that allow for such motion.

When evaluating any film, it is important to have an image in your mind of the normal anatomy. This is helpful when identifying dislocations of the shoulder. Visualize that the humeral head is sitting adjacent to the glenoid if the humeral head is shifted forward or anteriorly; it changes the appearance of the humeral head and proximal end of the humerus on radiograph. In the AP view, the head of the humerus will be under the coracoid and displaced toward the coracoid on the “Y” view. More than 95% of shoulder dislocation occurs anteriorly, with the displacement of the humeral head anterior to the glenoid cavity.

There are four types of anterior dislocations: subcoracoid, subglenoid, subclavicular, and intrathoracic, with the first two being the most commonly occurring. Anterior dislocations occur when indirect force to the arm is combined with abduction, extension, and external rotation of the arm. They may be accompanied by an impaction fracture of the anterior lip of the humeral head known as a Bankart fracture. Another commonly seen fracture associated with anterior dislocation is the Hill–Sachs defect, which is a fracture to the posterior–lateral aspect of the humeral head. This occurs when the humeral head is struck against the glenoid (Figure 7.29).

If the humeral head is shifted backward and is facing posteriorly, again, it changes the appearance of the humerus on a radiograph. With a posterior dislocation, the humeral head and proximal end of the humerus will have the appearance of a light bulb, especially in the AP view, and will be outside of the Y of the scapula on the “Y” view. There may be widening of the joint, usually greater than 6 mm, due to the lateral displacement of the humeral head. With approximately 3% of dislocations occurring posteriorly, they are very uncommon. It is caused by internal rotation and adduction from an indirect force. It may occur during a seizure, fall, or electrical/lightning shock. This type of dislocation may be difficult to identify on plain radiographs. Obtaining an axillary view is most beneficial (Figure 7.30).
FIGURE 7.29 Four types of anterior dislocation: subcoracoid (A); subglenoiod (B); subclavicular (C); and intrathoracic (D).

Source: Campo and Lafferty (2016).

FIGURE 7.30 Three views demonstrating a posterior dislocation.

Source: Theresa M. Campo.
Injury to the acromioclavicular ligament can cause a separation between the acromion and the clavicle. There are three grades of separation and they are:

**Grade I**—Minimal displacement of the joint may be visualized on radiograph. There is stretching and possibly partial tearing of the acromioclavicular ligament. This is the most common type of injury to this joint.

**Grade II**—The acromioclavicular ligament is completely torn but the coracoclavicular ligaments remain intact. This may be apparent on the radiographs as a widening of the acromioclavicular space. However, it may not be obvious during a physical exam.

**Grade III**—Complete separation of the joint occurs when the acromioclavicular and coracoclavicular ligaments are torn and there is damage to the surrounding capsule. This will be an obvious finding on the radiograph with widening of the acromioclavicular space. Clinically, a bump on the shoulder may be palpated due to the clavicle being pushed upward while the weight of the arm causes the shoulder to fall (see Figure 7.31).

![Figure 7.31](image-url)  
**FIGURE 7.31** Three grades of acromioclavicular (AC) separation; grade I (A); grade II (B); and grade III (C). Grade III AC separation on radiograph (D). Drawings courtesy of Theresa M. Campo. Image courtesy of Dr. Douglas W. Parrillo.
**Elbow**

The elbow is a large hinge joint that has two articulations. The first articulation is formed between the humerus and the ulna, which allows for flexion and extension. The second articulation is between the radius and humerus, which allows for supination and pronation. The elbow is stabilized by distinctive bony structures and ligaments that protect the joint from varying degrees of forces. It takes a great deal of force to cause a dislocation. For this reason, there are usually accompanying fractures of the radial head and coranoid process.

Approximately 90% of elbow dislocations occur posteriorly from a FOOSH-type injury. The other 10% of elbow dislocations may be anterior, divergent, medial, or lateral. Anterior dislocations usually occur from a direct blow to the posterior aspect of a flexed elbow and are commonly associated with brachial artery and median nerve injury. Divergent dislocations are extremely rare and caused by high-energy trauma to the elbow. Medial and lateral dislocations occur when the humerus is displaced either medially or laterally. See Figure 7.32 for an example of an elbow dislocation.

![Elbow dislocation](image)

**FIGURE 7.32** Elbow dislocation. Courtesy of Theresa M. Campo.

Nurse maid’s elbow is not a dislocation but a radial head subluxation. Nurse maid’s elbow can occur between the ages of 1 to 5 years of age but most commonly occurs in the child between 2 and 3 years of age. The annular ligament becomes torn from the radial head during a sudden pull on the forearm with the arm extended and minimally pronated. The torn annular ligament then slips between the radial head and the capetellum. This injury does not require medical imaging with a plain radiograph unless the mechanism is of a direct blow or other traumatic event. Ultrasound is being used to identify nurse maid’s elbow and confirm reduction of the annular ligament. However, clinical correlation with use of the arm again, following closed reduction, is typically confirmatory.
**Wrist**

Lunate and perilunate dislocations occur most frequently from a FOOSH but may also occur from a direct blow to the palm of the hand, causing dorsiflexion and ulnar deviation. Perilunate dislocations occur two to three times more frequently than lunate dislocations. Lunate dislocations occur when the lunate displaces volarly and rotates up to 90° from both the capitate and radius. Lunate dislocations are best seen in the lateral view with typical radius—lunate—capitate lines of the bones rotating medially and distally (Figure 7.33). Perilunate dislocations occur when the capitate is displaced from the lunate, most commonly toward the dorsal surface. Perilunate dislocations are also best visualized on the lateral view with the lunate in proper alignment with the radius with accompanying capitate dislocation. The AP view shows crowding of the carpals with overlapping of the proximal and distal rows. Approximately 75% of perilunate dislocations have an associated scaphoid fracture (Figure 7.34).

**Phalanges**

Dislocation can occur at any of the phalangeal joints and are considered either simple or complex. In simple dislocations, there is no soft tissue entrapment within the joint. When soft tissue becomes entrapped in the joint, the dislocation is considered to be complex and reduction may be quite difficult. Dislocation of metacarpal phalangeal/interphalangeal (MCP/IP) joints is described by the specific affected joint and the direction of the distal phalanx.

![Figure 7.33](image1.png)

**FIGURE 7.33** (A) and (B) demonstrate a lunate dislocation.

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FIGURE 7.34 (A) through (C) demonstrate a perilunate dislocation.
Source: University of Virginia. Permission granted by the University of Virginia Department of Radiology and Medical Imaging.
It is important to note that any fracture or dislocation that is reduced should have a postreduction radiograph to confirm realignment and reduction. Postreduction images can also rule in or out an accompanying fracture that was not visible due to the dislocation. Depending on the extent and stability of the fracture and/or dislocation, the postreduction film may need to occur either before or after a splint or cast has been applied.

**BONE LESIONS**

When evaluating the bone structures, growths of a benign or malignant etiology may be identified. When evaluating a bony lesion on radiograph, one should consider if the margins are ill-defined, well-defined, or sclerotic. Next, consider the patient’s age and, finally, where the lesion is located. Well-defined and sclerotic lesions in individuals younger than 40 years of age are usually benign with the exception of a well-defined chondrosarcoma, which occurs most often between the ages of 20 and 40 years. Ill-defined lytic lesions or any new bony lesions after the age of 40 years are highly suspicious for malignancy or metastasis and should have further evaluation (see Figure 7.35).

**FIGURE 7.35** Ill-defined (A1) and well-defined lytic lesion great toe (A2); rim sclerotic lesion enchondroma right femur (B); and sclerotic lesions (C). Courtesy of Dr. Douglas W. Parrillo; diagramming, Theresa M. Campo.
CONCLUSION

Falls and direct trauma are the most common causes of injury to the upper extremities. There are many terms used to identify types of fractures and dislocations. The important thing to remember is to clearly describe, using correct anatomical terminology, what is visualized on an image and not become overly concerned about the “proper name” of a fracture or dislocation. Proper identification of the bone, area of the bone, and type of fracture is all that is needed to discuss your findings with colleagues and radiologists. The ability to properly identify normal anatomical structures is paramount to understanding what you are visualizing on a radiograph and why. Always match the mechanism of injury with the findings themselves. If a mechanism does not match the findings, then suspicion for abuse is necessary and warranted. Keep looking at upper extremity films to improve your interpretation proficiency and confidence. Have fun!

RESOURCES


