



Pediatric Upper Extremity Trauma Imaging: Building Blocks for the Developing Radiologist

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Abstract

Pediatric upper extremity injuries are among the most common reasons for emergency department visits in children, often resulting from falls, sports activities, or non-accidental trauma. The unique anatomical and physiological characteristics of the growing skeleton, including the presence of open growth plates, secondary ossification centers, and developing cartilage, present both diagnostic challenges and opportunities for radiologists. Accurate imaging evaluation is crucial not only for identifying fractures but also for recognizing subtle patterns that may indicate more serious pathology, such as physeal injuries or child abuse. Radiographs remain the first-line imaging modality, but advanced techniques such as ultrasound and MRI play an increasingly important role in evaluating soft tissue injuries, growth plate disruptions, and occult fractures. The use of low-dose CT and tailored protocols further aids diagnosis while minimizing radiation exposure. Understanding the normal developmental anatomy, especially in complex regions like the elbow where multiple ossification centers appear in a predictable sequence is essential to avoid misinterpretation. Furthermore, recognizing age-specific injury patterns such as buckle fractures, supracondylar fractures, and Monteggia variants is critical for accurate reporting and appropriate management. Classification systems like Salter-Harris remain indispensable tools for describing fracture patterns involving the physis. The radiologist must also remain alert to red flags for non-accidental trauma, particularly in infants and toddlers, where imaging findings may be the first or only indicator of abuse. This article provides a comprehensive review of imaging strategies, developmental considerations, common injury patterns, classification systems, complications, and the evolving role of radiologists in the multidisciplinary care of pediatric patients with upper extremity injuries. Emphasis is placed on the integration of anatomical knowledge, imaging acumen, and clinical context to ensure precise diagnosis and optimal outcomes for pediatric patients.

Keywords: Pediatric trauma, upper extremity injuries, radiology, growth plate, salter-harris fracture, supracondylar fracture, ossification centers, mri, ultrasound, child abuse, elbow injuries, greenstick fracture, monteggia, radiographic interpretation, non-accidental trauma

Introduction

Pediatric upper extremity injuries are a leading cause of hospital visits among children and adolescents, accounting for a significant proportion of trauma-related emergency department admissions worldwide. The upper extremities comprising the shoulder, arm, elbow, forearm, wrist, and hand are particularly vulnerable during common childhood activities such as playground use, sports, and recreational events. Studies have shown that nearly half of all pediatric fractures occur in the upper limbs, with the distal forearm, elbow, and hand being the most commonly affected regions [1, 2]. While most of these injuries are benign and heal well with appropriate management, timely and accurate imaging is essential to avoid long-term complications such as growth disturbances, joint dysfunction, and deformity.

The pediatric musculoskeletal system differs fundamentally from that of adults due to ongoing skeletal development, the presence of open growth plates (physes), and the gradual ossification of cartilage into bone. These anatomical and physiological distinctions require radiologists to be well-versed in age-specific imaging interpretation and developmental anatomy to avoid diagnostic errors. For example, the appearance of secondary ossification centers can easily be mistaken for fractures if normal developmental timelines are not considered [3]. Moreover, injury

mechanisms vary by age; younger children are more prone to buckle or greenstick fractures due to bone pliability, whereas adolescents are more likely to sustain complete fractures and ligamentous injuries associated with higher-energy trauma [4]. Radiographic assessment remains the cornerstone of initial evaluation, yet its diagnostic utility is heavily dependent on correct positioning, appropriate technique, and detailed knowledge of pediatric norms. In complex or equivocal cases, modalities such as ultrasound and magnetic resonance imaging (MRI) provide valuable information regarding soft tissue integrity, cartilaginous components, and occult injuries that are not visible on plain films [5]. Computed tomography (CT), though less favored due to radiation risks, is selectively used when high-resolution bony detail is required, especially in trauma settings or preoperative planning [6]. Additionally, radiologists play a critical role in identifying signs of non-accidental trauma (NAT), which can present as subtle, isolated upper extremity injuries. A high index of suspicion and thorough documentation are necessary, as imaging findings may be the first clue in uncovering cases of child abuse [7]. As the complexity of pediatric imaging grows, so does the need for radiologists to stay informed about evolving techniques, classification systems, and evidence-based protocols.

Imaging Modalities in Pediatric Upper Extremity Injuries

Conventional Radiography as the Cornerstone of Initial Evaluation

Conventional radiography remains the most widely used and essential imaging modality in evaluating pediatric upper extremity injuries due to its accessibility, speed, and diagnostic utility. Radiographs provide critical insight into bone alignment, cortical integrity, and fracture configuration. They are the first-line imaging tool in emergency and outpatient settings, offering high diagnostic yield for common injury types such as greenstick, buckle, and supracondylar fractures^[8]. A thorough understanding of pediatric skeletal development is vital during interpretation, as the presence of cartilaginous growth plates, unfused epiphyses, and multiple ossification centers can mimic pathology. Errors often arise when these normal variants are misinterpreted as fractures. Standard views including anteroposterior (AP) and lateral projections should be carefully obtained and assessed, with additional oblique or contralateral comparison views employed when necessary. Because pediatric patients may have difficulty cooperating due to pain or fear, the radiographer must employ age-appropriate immobilization techniques, child-friendly communication, and parental support to ensure proper positioning and minimize motion artifacts^[9].

Ultrasound for Real-Time Assessment of Soft Tissues and Occult Injuries

Ultrasound is an invaluable tool in pediatric musculoskeletal imaging, particularly for evaluating soft tissue structures, non-ossified cartilage, and fluid collections. Unlike radiography, which primarily assesses bone, ultrasound excels in detecting joint effusions, ligamentous injuries, and subtle fractures not evident on X-rays. In upper extremity trauma, it is frequently used to assess elbow joint effusions that may suggest an occult supracondylar fracture or intra-articular pathology^[10]. Its advantages include being radiation-free, non-invasive, portable, and capable of real-time dynamic imaging. It is particularly useful in children under five, where incomplete ossification renders conventional radiography less effective. Furthermore, ultrasound allows for functional assessment during joint movement and can guide procedures such as fluid aspiration or hematoma evacuation.

Computed Tomography for Complex Fractures Requiring Detailed Bony Evaluation

CT scanning provides superior spatial resolution for evaluating intricate bony anatomy and is typically reserved for complex upper extremity injuries, especially when detailed assessment of fracture patterns, displacement, or intra-articular extension is required. Indications for CT include suspected comminuted fractures, elbow fracture-dislocations, and cases where surgical intervention is anticipated and radiographs are inconclusive^[11]. However, its use in pediatric imaging is tempered by the risks associated with ionizing radiation. Children are more sensitive to radiation, and cumulative exposure can increase the lifetime risk of malignancies. Therefore, CT should be

employed selectively, with adherence to the ALARA (As Low as Reasonably Achievable) principle and use of pediatric-specific protocols that minimize dose while maintaining diagnostic quality.

Magnetic Resonance Imaging for Detailed Evaluation of Cartilage, Ligaments, and Growth Plates

MRI is the imaging modality of choice for detailed soft tissue evaluation and is particularly beneficial in the pediatric population where much of the skeletal structure remains cartilaginous. It provides superior contrast resolution for visualizing bone marrow, ligaments, tendons, and cartilage, and is critical in detecting occult fractures, ligamentous injuries, growth plate disruptions, and osteochondral lesions that may not be visible on plain radiograph^[12]. MRI is especially useful in evaluating chronic or subacute injuries in adolescents engaged in sports or in cases of suspected overuse injuries. Additionally, its role in assessing the integrity of the physis is unmatched, allowing early detection of subtle injuries that may result in growth disturbances if left untreated.

Fluoroscopy and Arthrography for Targeted Evaluation in Specialized Cases

Fluoroscopy and arthrography are specialized imaging techniques with specific indications in pediatric upper extremity evaluation. Fluoroscopy is primarily used intraoperatively to guide fracture reduction, hardware placement, or joint manipulation. It allows real-time visualization of joint dynamics, which can be helpful in assessing instability or evaluating range of motion following trauma or surgical intervention. Arthrography, on the other hand, involves the injection of contrast material into a joint to outline intra-articular structures, aiding in the assessment of cartilage defects, ligament tears, or labral abnormalities in partially ossified joints^[13].

Developmental and Anatomical Considerations

Ossification centers of the upper limb (e.g., elbow CRITOE)

The appearance and sequencing of ossification centers in the pediatric upper extremity, particularly around the elbow, are central to accurate radiographic interpretation. The elbow ossifies in a predictable chronological pattern best remembered by the CRITOE mnemonic: capitellum, radial head, internal (medial) epicondyle, trochlea, olecranon, and external (lateral) epicondyle, typically appearing at approximate ages of 1, 3, 5, 7, 9, and 11 years, respectively^[14]. Each ossification center has unique characteristics in morphology and timing, which can create diagnostic confusion in trauma cases. For example, the trochlea may appear fragmented or irregular due to its cartilaginous origin and bipartite development, but these findings are frequently normal. Misinterpretation of normal ossification as pathology can lead to unnecessary investigations or inappropriate management. Knowledge of these patterns and careful comparison with the contralateral limb when in doubt can help radiologists distinguish normal development from fracture fragments or avulsion injuries^[15] (Figure 1).

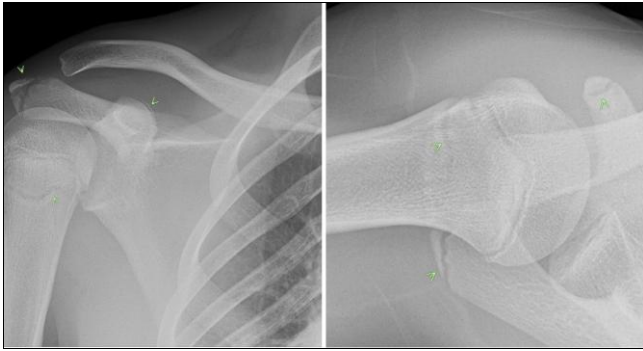


Fig 1: Frontal and axial radiographs of right shoulder show ossification centers of the coracoid, acromion and proximal humeral physis which are not to be mistaken for fractures in immature skeleton.

Normal variants versus pathology

A critical challenge in pediatric musculoskeletal imaging is the differentiation between normal anatomical variants and true pathological findings. Pediatric bones often present radiographic features such as cortical irregularities, pseudo-widened physes, accessory ossification centers, or metaphyseal beaking, which may mimic fractures or other disease processes [16]. Without awareness of these variants and their common presentation at certain developmental stages, misdiagnoses are frequent. Clinical correlation and contralateral imaging are essential strategies in ambiguous cases, as is a strong foundational understanding of pediatric bone physiology and growth [17].

Physal growth plates and their vulnerability

The physis, or growth plate, is a specialized cartilaginous structure found at the ends of long bones, responsible for longitudinal skeletal growth. Because of its histological composition and biomechanical weakness relative to surrounding bone, it is particularly vulnerable to injury in children [18]. Trauma to the physis can result in Salter-Harris type fractures, which vary in severity and prognosis depending on the involvement of the metaphysis, epiphysis, or both. Physal injuries are often subtle and may not be readily apparent on conventional radiographs due to the radiolucent nature of cartilage. However, missed or misdiagnosed growth plate injuries can lead to serious consequences such as growth arrest, angular deformities, or joint incongruity, particularly when involving the distal radius, proximal humerus, or distal humerus [19].

Age-related imaging interpretation challenges

Interpreting pediatric imaging demands an age-specific approach because developmental anatomy and the radiologic appearance of bones change significantly from infancy through adolescence. In younger children, the high cartilaginous content and incomplete mineralization result in pliable bones prone to unique fracture types such as greenstick, torus, or plastic bowing deformities, which may be subtle and difficult to detect [20]. As children mature into adolescence, bones become denser and more similar to adult bones in appearance, and the growth plates begin to close. This results in more complex fractures and the potential for adult-type injury mechanisms, including ligamentous injuries or joint dislocations.

Common Pediatric Upper Extremity Injuries

Clavicle Injuries

Clavicle fractures are among the most common skeletal injuries in the pediatric population and frequently occur as a result of falls onto an outstretched arm or direct trauma to the shoulder. In neonates, clavicle injuries are often related to birth trauma, particularly in difficult deliveries involving shoulder dystocia, where midshaft fractures are the most typical manifestation [21]. In older children, midshaft fractures are again the most prevalent, given the relatively thin and curved diaphyseal structure. Management is usually conservative, utilizing slings or figure-of-eight bandages, as children have excellent healing potential with remodeling capabilities.

Shoulder and Proximal Humerus

Proximal humerus injuries in children typically result from falls or high-impact trauma and may involve the growth plate, metaphysis, or epiphysis depending on the patient's age. Due to the thick periosteum and the high cartilage content, fractures may appear subtle radiographically. Salter-Harris fractures of the proximal humerus are particularly important due to the proximity of the growth plate and its substantial role in upper arm growth contributing nearly 80% of humeral longitudinal development [22]. The remodeling capacity of the proximal humerus is high in young patients, so even moderately displaced fractures often heal well with closed reduction and immobilization.

Elbow Injuries

Elbow trauma is a frequent cause of emergency department visits in pediatric patients, with supracondylar fractures being the most common type. These fractures, resulting from hyperextension injuries, often occur in children aged 5–7 years and may be classified into types based on displacement and cortical integrity [23]. Radiographs reveal posterior displacement of the distal humeral fragment and may show a “sail sign” or posterior fat pad indicating joint effusion. Lateral condyle fractures, which may be missed due to subtle initial displacement, are dangerous because they can progress to nonunion or lead to lateral overgrowth if not treated promptly. Medial epicondyle avulsion injuries are often associated with elbow dislocation and can present as small ossification centers misinterpreted as fracture fragments [24]. (Figure 2 and 3)



Fig 2: Frontal and lateral radiographs of elbow show a fracture across the supracondylar region with mild posterior angulation and associated elevation of the anterior and posterior fat pads reflecting joint effusion.

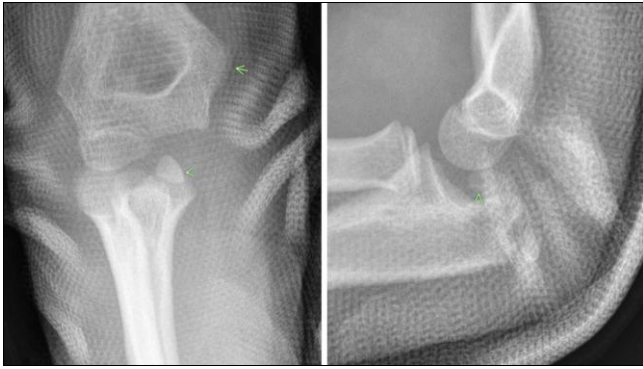


Fig 3: Frontal and lateral radiographs of splinted elbow show an avulsion fracture of the medial epicondyle that has been inferiorly distracted and entrapped within the ulno-humeral joint. This is particularly important to recognize as missed diagnosis can lead to significant morbidity.

Forearm and Wrist Injuries

Pediatric forearm fractures frequently involve the radius, ulna, or both and occur due to falls or sports injuries. Buckle (torus) fractures, characterized by cortical bulging due to axial loading, are common in younger children and appear as subtle bulges on radiographs without cortical disruption [25]. Greenstick fractures, on the other hand, involve an incomplete break with bending of the cortex on one side and disruption on the other, reflecting the pliability of pediatric bone. These are particularly prone to angulation and require proper immobilization. Galeazzi injuries consist of a distal radial shaft fracture accompanied by dislocation of the distal radioulnar joint, and while uncommon, they can be misdiagnosed if the distal ulna is not carefully evaluated [26] (Figure 4).

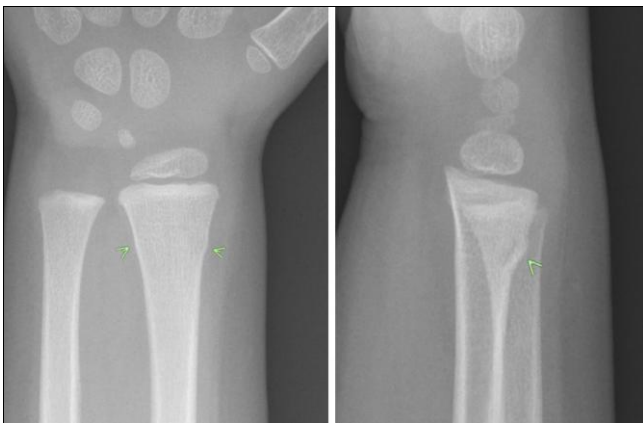


Fig 4: Frontal and lateral radiographs of the wrist show a buckle fracture of the distal metadiaphysis with a small wrist joint effusion.

Hand and Finger Injuries

The pediatric hand and fingers are vulnerable to both blunt and sharp trauma, especially during play and sporting activities. Salter-Harris fractures involving the phalanges are common and can often be managed non-operatively, but accurate classification is important to avoid complications such as growth disturbance or joint stiffness [27]. Avulsion injuries at tendon attachment sites can mimic minor trauma but may involve displaced bone fragments and require surgical attention if the extensor mechanism is compromised.

Fracture Classifications Relevant to Pediatric Radiology Salter-Harris Classification

The Salter-Harris classification is the most widely used system to describe fractures involving the growth plate (physis) in children and adolescents. It is particularly crucial in pediatric radiology because of the implications such fractures have for future bone growth and development. This system comprises five primary types ranging from Type I, which is a transverse fracture through the physis with no bone involvement, to Type V, which is a crush injury to the physis with the highest risk of growth arrest [28]. Type II, the most common, extends through the physis and metaphysis, while Type III involves the physis and epiphysis, and Type IV extends through all three: metaphysis, physis, and epiphysis. Type V injuries are often difficult to identify on initial radiographs and may only become evident retrospectively when growth disturbance occurs. Accurate recognition and classification using the Salter-Harris system help guide appropriate treatment and long-term monitoring for complications such as angular deformities and limb length discrepancies [29].

AO Pediatric Classification

The AO Pediatric classification is a more comprehensive system developed to address the limitations of older fracture classification schemes by integrating fracture morphology, location, and severity in growing bones. It is part of the AO Pediatric Comprehensive Classification of Long Bone Fractures (PCCF), which uses a code-based system to describe the bone segment (e.g., diaphysis, metaphysis, epiphysis), fracture pattern (e.g., transverse, oblique, spiral), and involvement of the physis or joint [30]. This system is valuable in research and multicenter clinical studies because it allows for standardized data collection and outcome comparison.

Displacement, Angulation, and Remodeling Potential

In pediatric radiology, assessing displacement and angulation of fractures is essential to determine the need for intervention and predict healing outcomes. Displacement refers to the degree to which bone fragments have shifted from their normal anatomical alignment, while angulation describes the angle formed between the fracture fragments. Pediatric bones have a remarkable capacity for remodeling, particularly in younger children and in fractures near joints where growth is active [31]. For instance, mild to moderate angulated fractures in the distal radius of a 5-year-old may completely remodel within months. However, fractures with significant displacement, particularly those involving the articular surface or growth plate, often require more precise reduction to prevent long-term functional limitations.

Red Flags: Child Abuse and Non-Accidental Trauma Imaging Patterns Suspicious for Abuse

Non-accidental trauma (NAT), also referred to as child abuse, is a critical diagnostic concern in pediatric radiology. Radiologists must maintain a high index of suspicion when interpreting images that present with atypical fracture patterns, especially in non-verbal or pre-ambulatory children. Certain injury patterns have been consistently associated with abuse rather than accidental trauma. These include multiple fractures at different stages of healing, fractures inconsistent with the reported mechanism of injury, and injuries in non-mobile infants [32]. A

comprehensive skeletal survey, following standardized protocols such as those established by the American College of Radiology (ACR), is the cornerstone of imaging evaluation in suspected cases of NAT [33].

Metaphyseal Corner Fractures

Metaphyseal corner fractures, also known as "bucket handle" fractures, are highly specific indicators of non-accidental trauma in infants and young children. These injuries typically occur at the metaphyseal regions of long bones, such as the distal femur, proximal tibia, and proximal humerus, and are believed to result from violent shearing or traction forces, such as those that occur during shaking or jerking of the limbs (34). These fractures are often radiographically subtle, appearing as thin, linear lucencies or fragments parallel to the growth plate, and are best detected using high-resolution imaging.

Posterior Rib Fractures

Posterior rib fractures are another hallmark of non-accidental trauma, typically associated with repetitive squeezing or compressive forces applied to the infant's chest. These injuries occur near the costovertebral junctions and are uncommon in accidental trauma or typical falls, particularly in non-ambulatory children [35]. The presence of multiple posterior rib fractures, especially in the absence of appropriate trauma history, strongly suggests inflicted injury.

Role of the Radiologist in Documentation and Reporting

Radiologists play a central role in the multidisciplinary approach to child abuse, serving as objective medical experts who interpret imaging findings within clinical and forensic contexts. Beyond image interpretation, their responsibilities include thorough documentation of all suspicious findings, comparison with prior imaging (if available), and clear communication with referring physicians and child protection teams. Reports should be precise, using descriptive language that accurately conveys the nature and location of injuries, and avoid ambiguous terminology that may weaken the clinical impression [36]. In many jurisdictions, radiologists are mandated reporters, meaning they are legally required to report suspected cases of abuse to appropriate child welfare authorities.

Complications and Sequelae

Growth Disturbances and Physeal Arrest: Growth disturbances are among the most significant long-term complications of pediatric upper extremity injuries, particularly those involving the growth plates (physes). The physis is responsible for longitudinal bone growth, and trauma to this region can lead to premature closure, also known as physeal arrest. This arrest may be partial or complete, leading to angular deformities, limb length discrepancies, or joint incongruity depending on the location and severity of injury [37]. Injuries classified under Salter-Harris types III, IV, and V are especially prone to causing such disturbances due to their involvement of both the epiphysis and the physis. Radiologic follow-up with serial imaging is essential to monitor for physeal closure over time. MRI plays a critical role in evaluating early signs of growth plate damage, even before they become radiographically apparent [38].

Malunion and Nonunion

Malunion and nonunion are complications of improperly healed fractures and are less common in children compared to adults due to their superior healing capacity. However, when they do occur, they can significantly impair limb function and development. Malunion refers to healing in an incorrect position, potentially leading to cosmetic deformities, altered biomechanics, and reduced range of motion [39]. Nonunion, the failure of a fracture to heal within the expected time frame, is rare in children but can occur in the presence of infection, poor vascularity, or underlying bone pathology. Radiographically, malunion appears as angulated or rotated bone segments, while nonunion is characterized by persistent fracture lines with sclerotic margins and absence of bridging callus. (Figure 5).

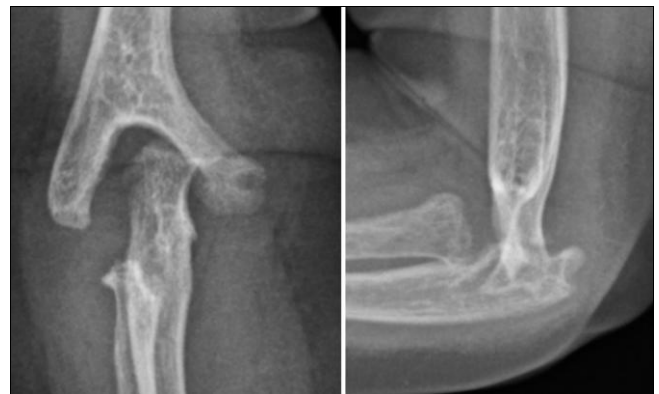


Fig 5: Fishtail deformity. Frontal and axial radiographs of elbow show resorption of the central portion of distal humerus with reciprocal changes and proximal migration of proximal ulna and radius. Findings represent uncommon complication of distal humeral fracture.

Osteomyelitis and Septic Arthritis

Infection is a serious complication that may arise after open fractures, penetrating trauma, or surgical interventions. Osteomyelitis, or bone infection, typically presents with localized pain, swelling, fever, and elevated inflammatory markers. Septic arthritis, the infection of a joint space, is an emergency that can lead to irreversible cartilage damage and joint destruction if not promptly treated (40). Post-traumatic infections often present subtly, making early radiologic evaluation critical. Initial radiographs may be normal, but MRI is highly sensitive for detecting early osteomyelitis and joint effusions.

Neurovascular Complications

Neurovascular injuries, though rare, can have devastating consequences if not promptly recognized and managed. These complications are most frequently associated with high-energy trauma or displaced fractures, particularly around the elbow and shoulder. For instance, supracondylar humerus fractures pose a risk to the brachial artery and median nerve, while shoulder dislocations and proximal humerus fractures can endanger the axillary nerve and artery [41]. Clinical signs such as absent pulses, pallor, paresthesia, or motor deficits warrant immediate vascular imaging.

Radiologist's Role in Multidisciplinary Management Communication with Orthopedic and Emergency Teams

The radiologist plays a central role in the multidisciplinary management of pediatric upper extremity injuries by ensuring timely and precise communication with orthopedic

surgeons, emergency physicians, and pediatricians. Because pediatric fractures often present with subtle or complex radiologic features that can be easily misinterpreted, it is the responsibility of the radiologist to promptly and clearly convey critical findings that may influence immediate or surgical management decisions ^[42]. Structured reporting systems and direct consultations especially in emergency settings improve decision-making and coordination of care.

Guiding Further Imaging or Referrals

Radiologists not only interpret initial imaging but also determine the necessity for further diagnostic evaluation. Certain pediatric injuries, particularly those involving the physis, cartilage, or subtle epiphyseal abnormalities, may not be adequately visualized on plain radiographs. In such cases, the radiologist guides the use of adjunctive imaging modalities such as ultrasound, MRI, or CT to provide more detailed anatomical assessment ^[43].

Monitoring Healing and Complications

Follow-up imaging is often necessary in the pediatric population to monitor the progression of fracture healing, assess the alignment, and identify early signs of complications such as growth arrest, malunion, or infection. Radiologists are crucial in interpreting these serial images and comparing them with prior studies to determine whether healing is progressing normally or if additional intervention is warranted ^[44]. Prompt identification of delayed union or abnormal physeal closure allows clinicians to intervene early and prevent long-term disability.

Educating Clinicians on Pediatric-Specific

Interpretations: Pediatric musculoskeletal imaging differs significantly from adult imaging due to developmental anatomy, presence of ossification centers, and variability in skeletal maturation. Radiologists have a responsibility to educate non-radiologist clinicians especially those in emergency and general practice on how to distinguish normal developmental variants from pathology ^[45]. Through interdisciplinary meetings, imaging rounds, and integrated training programs, radiologists help elevate the diagnostic accuracy of the entire care team.

Future Directions and Technological Advances

AI and Machine Learning in Pediatric Trauma Imaging

Artificial intelligence (AI) and machine learning (ML) are increasingly transforming pediatric radiology by offering advanced tools for faster, more accurate, and standardized image interpretation. In pediatric trauma imaging, AI algorithms are being developed to automatically detect fractures, classify injury types, and even predict healing outcomes ^[46]. These systems can assist radiologists by flagging subtle findings that may otherwise be missed, particularly in busy emergency departments.

Low-Dose Protocols and Image Optimization

Radiation safety remains a top priority in pediatric imaging due to the increased sensitivity of children to ionizing radiation and the long-term risks associated with cumulative exposure. Recent technological advances have focused on the development and implementation of low-dose imaging protocols that maintain diagnostic quality while significantly reducing radiation doses ^[47]. Digital radiography systems, automatic exposure control, and

iterative reconstruction algorithms in CT imaging allow clinicians to adhere to the ALARA (As Low as Reasonably Achievable) principle without compromising diagnostic accuracy.

Advanced MRI Techniques for Cartilage and Ligament Injuries

Emerging MRI technologies, such as 3D isotropic imaging, quantitative cartilage mapping (e.g., T2 mapping, dGEMRIC), and MR arthrography, have significantly improved visualization of immature joint structures ^[48]. These techniques are especially valuable for detecting early cartilage injury, ligament tears, or growth plate disruptions in the shoulder, elbow, and wrist areas commonly affected in sports-related or traumatic incidents.

Point-of-Care Ultrasound (POCUS) in Emergency Pediatrics

Point-of-care ultrasound (POCUS) is gaining traction as a rapid, non-invasive, and radiation-free tool in pediatric trauma assessment, particularly in emergency and bedside settings ^[49]. In musculoskeletal injuries, POCUS can aid in identifying occult fractures, assessing ligamentous injuries, and guiding joint aspirations or hematoma blocks. Its real-time imaging capability, coupled with portability and ease of use, makes it an ideal first-line tool in unstable or non-cooperative pediatric patients. Additionally, training programs are equipping pediatric emergency clinicians with the skills to perform and interpret basic musculoskeletal POCUS, expanding its clinical utility beyond radiology departments ^[50].

Conclusion

Pediatric upper extremity injuries present a unique and complex challenge in diagnostic radiology dynamic anatomy, variable ossification patterns, and vulnerability due to the of growing bones. Radiologists play a pivotal role in ensuring accurate diagnosis, appropriate classification, and timely communication with the clinical team, all of which are essential for optimal patient outcomes. The importance of understanding growth plate anatomy, especially the susceptibility of the physis to injury and the long-term consequences of physeal disturbances, cannot be overstated. Missed or misinterpreted injuries in this population can result in significant complications such as growth arrest, angular deformities, functional limitation, or even the need for corrective surgery. Moreover, the radiologist must maintain heightened vigilance for red flag signs that may suggest non-accidental trauma, as early identification and proper documentation are critical to safeguarding vulnerable children. The radiologist's contributions extend beyond imaging interpretation to guiding clinical management, monitoring healing progression, recognizing early signs of complications like malunion, infection, or neurovascular compromise, and educating referring clinicians on pediatric-specific imaging principles. As the field of pediatric radiology continues to evolve, integration of advanced technologies—such as artificial intelligence for automated detection, low-dose imaging protocols to reduce radiation burden, and sophisticated MRI techniques for cartilage and ligament evaluation—will further enhance diagnostic capabilities. Additionally, the increasing use of point-of-care ultrasound

in emergency settings offers radiologists new opportunities to support frontline care. To keep pace with these advancements and to maintain a high standard of care, radiologists must engage in continuous education and interdisciplinary collaboration. Ultimately, the accurate and empathetic practice of pediatric radiology not only improves immediate clinical outcomes but also safeguards the long-term musculoskeletal development and overall well-being of pediatric patients.

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