"RAMBO" Lesions: Radiographic Anomalies Missed by Orthopaedists

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Abstract: Orthopaedic training involves frequent evaluation of radiographs, but even a seasoned orthopedist has the potential to miss certain anomalies on radiographic images. Radiographs of skeletally immature patients offer challenges in interpretation to general orthopaedic providers who may be unfamiliar with the evolving ossification of younger patients. We propose the term "RAMBO" lesions, or radiographic anomalies from traumatic pediatric injuries that can be missed by an orthopaedist. While the list is practically limitless, the purpose of this article is to review a series of radiographic findings commonly missed in pediatric trauma. These cases serve to remind us to continue vigilance and to maintain a high index of suspicion when evaluating injured children.

Key Concepts:

- There is a potential for radiographic anomalies to be missed by orthopaedists, and some missed injuries may have serious complications.
- Additional advanced imaging may be needed if initial radiographs are insufficient.
- Awareness and a high clinical suspicion remain the most important tools for preventing radiographic anomalies missed by orthopaedists.

Introduction

Orthopaedists are skilled radiographic diagnosticians, but even a seasoned orthopaedist has the potential to miss certain anomalies. Radiographs of skeletally immature patients offer additional challenges in interpretation as many non-pediatric providers may be unfamiliar with the radiographic anatomy of younger patients. Examples of radiographic abnormalities commonly missed by emergency medicine physicians and radiologists have been published.[1-3] There are fewer published studies from the vantage point of the orthopaedist where subtle abnormalities are missed on "normal" radiographs or when adjacent to obvious findings.[4] Understanding the characteristics of pediatric radiographs and a high index of clinical suspicion help prevent missing certain subtleties on radiographs.

For the purpose of this paper, RAMBO lesions, or **R**adiographic **A**nomalies **M**issed **B**y **O**rthopaedists, are defined as traumatic pediatric injuries that can be missed by an orthopaedist and that misdiagnosis can lead to morbidity such as malunion, increased need for surgical procedures, or osteonecrosis of a large joint.[5-18] S. Terry Canale, MD, coined the acronym RAMBO in the early 1980s when his observation of the number of pediatric conditions missed on radiographs coincided with the release of the first Rambo movie. At our institution, we have observed a subset of these injuries on a more

frequent basis, and the purpose of this article is to review examples of traumatic pediatric radiographic anomalies missed by orthopaedists with the aim of educating orthopaedic surgeons and preventing these and other radiographic anomalies from being missed.

Cases

A panel of six experienced pediatric orthopaedic surgeons (each with up to 35 years of individual experience) came together and, as a group, identified five traumatic injuries that they have seen more frequently throughout their careers as RAMBO lesions. These include transphyseal fracture of the distal humerus, Monteggia injury, entrapped medial epicondylar fracture of the elbow, hip dislocation with incongruous hip after reduction, and lower extremity ipsilateral second fracture. Although other injuries and bony lesions can be missed on radiographs, the five we have chosen from our collective experience also have the potential for significant morbidity if the diagnosis is delayed or missed.

Figure 1. *This 2.5-year-old boy has a medially displaced transphyseal fracture of his distal humerus. While this fracture could be displaced posterolaterally, fracture dislocations of the lateral condyle are almost always laterally displaced. Unfortunately, the associated forearm fracture and abdominal bruising confirm NAT.*

Transphyseal Fractures of the Distal Humerus

Fractures around the elbow in pediatric patients are common,[17,19] but transphyseal fractures of the distal humerus are easily missed and generally occur in patients younger than 3 years of age.[20] These injuries occur in the same area as supracondylar humeral fractures in older children.[18] Most of the distal humerus at this young age is cartilaginous, and the physis is weaker than the bone ligament interface.[17,20,21] The birthing process or a difficult delivery can be the cause of this injury,[3,22,23] as well as a fall in a toddler.[3,24] However, because this transphyseal injury may be associated with non-accidental trauma,[24-26] missing this radiographic anomaly can have devasting consequences, and a high index of suspicion is required. These injuries can be missed completely or misdiagnosed as elbow dislocations which are rare in toddlers.[17,20,24,27] Transphyseal fracture of the distal humerus can also be misdiagnosed as a lateral condylar fracture.[18]

An orthopaedist may incorrectly identify subtleties on pediatric elbow films in young patients[4] and incorrectly diagnose a supracondylar humeral fracture.[3,24] Identifying the anatomic radiocapitellar relationship is essential when considering the differential diagnosis: elbow dislocation, lateral condylar fracture, or a transphyseal distal humeral fracture.[21] In the later injury, the fracture travels through non-ossified cartilage, so evaluating the relationship of the ossification centers and the radiocapitellar joint is important in diagnosis.[17] In the very young who suffer birth injury or non-accidental trauma, this diagnosis is hard to make as the anatomy is difficult to palpate, and the capitellum and radial head may not be ossified or visible in this age group.[21] (The capitellum is not visible until 1 or 2 years of age.[17])

Some clues are helpful to accurately characterize the injury in toddlers with some ossification. If the radiocapitellar joint is displaced, the child may have an elbow dislocation or a widely displaced lateral condyle fracture. If the radiocapitellar joint is intact, a transphyseal injury is suspected, especially if the capitellum is displaced medially; most fracture dislocations with a lateral condyle fracture go laterally (Figure 1).

On an anteroposterior (AP) radiograph, the long axis of the ulna is normally slightly medial to the long axis of the humerus.[17] If these two long axes do not align, but the radiocapitellar joint appears to be intact, a transphyseal separation of a supracondylar humeral fracture should be suspected.[17] In these injuries, the radial head and proximal ulna are displaced as a unit with the distal humerus.[18]

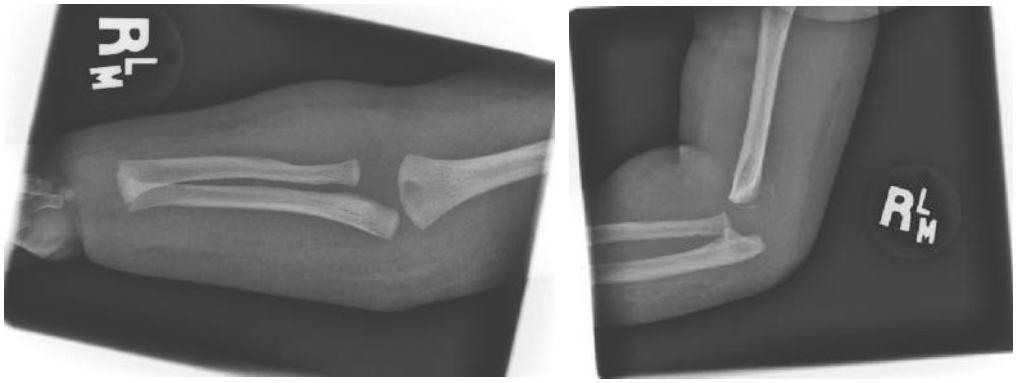


Figure 2a. *Anteroposterior radiograph of the right elbow in a 5-month-old female with concern for non-accidental trauma. The carrying angle in the AP plane is not obviously displaced.* ***Figure 2b.*** *Lateral radiograph of the elbow demonstrates a small metaphyseal spike which may suggest a transphyseal injury displaced posteriorly (extension style transphyseal injury).*

If a transphyseal fracture of the distal humerus is suspected but cannot be confirmed on radiographs (Figure 2), contralateral elbow images should be obtained for comparison, and an elbow ultrasound, elbow arthrogram, or MRI of the elbow can be obtained.[17,21] An elbow arthrogram performed in the operating room by an orthopaedist has the added advantage of immediate surgical intervention if needed. The recommended treatment for a transphyseal fracture of the distal humerus is reduction and percutaneous pinning and is made much easier when the cartilage of the distal humerus is outlined by arthrogram dye (Figure 3). If the diagnosis of transphyseal fracture of the distal humerus is made, a referral to pediatrics and a skeletal survey should be performed to continue the workup for non-accidental trauma.[21] The stakes are high especially for the child with possible non-accidental trauma.

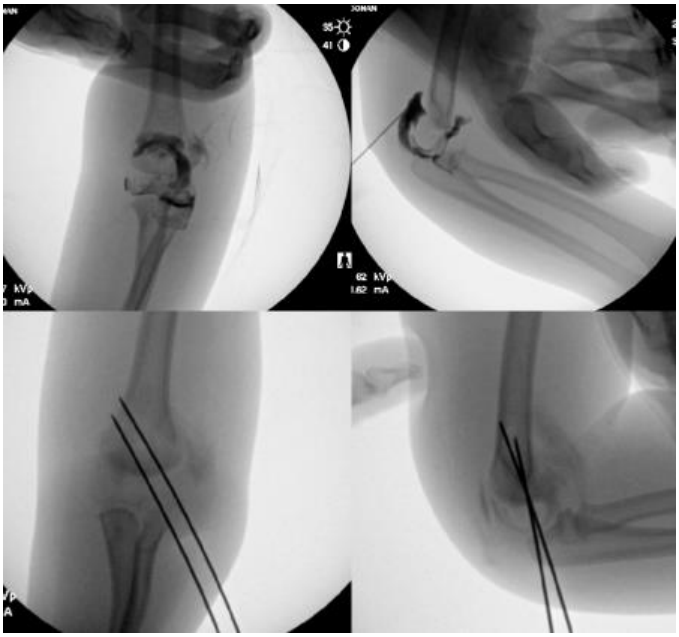


Figure 3. *Elbow arthrogram confirms a displaced transphyseal fracture and guides closed reduction and pinning.*

Monteggia Injury

First described by Giovanni Monteggia in 1814, this named injury describes a fracture of the ulna associated with dislocation of the radiocapitellar joint.[28,29] An orthopaedist should have a healthy respect for this injury because a missed diagnosis (Figure 4) can create a challenging situation with increased patient morbidity and surgical complexity as early as 2 weeks after the initial injury.[28]

The radiocapitellar line, or Storen line, is the intersection of a line drawn through the long axis of the radial shaft with the capitellum.[30] This line should bisect the capitellum in all radiographic views[17] and in infinite degrees of flexion and extension of the elbow.[31] An abnormal intersection of this line is used to suspect a radial head displacement but does not evaluate concurrent injury to the ulna.[3] There are anterior radial head dislocations that have an obvious ulnar fracture while others are less

obvious with only an "ulnar bow sign.[5] First described by Lincoln and Mubarak, on a true lateral radiograph, a straight line is drawn along the dorsal border of the ulna from the level of the olecranon to the distal ulnar metaphysis.[5] The maximal perpendicular distance of this line from the ulnar shaft is recorded.[5] An ulnar bow of more than 1mm should create a high index of clinical suspicion for injury to the ulna (e.g., plastic deformation (Figure 5).

A traumatic radial head dislocation or subluxation should be suspected if the posterior border of the ulna on a true lateral radiograph deviates more than 1mm from a straight line.[5] As a reference for a patient's normal elbow anatomy, contralateral elbow films can be helpful, especially in children younger than 10 years of age.[28]

The keys to avoiding morbidity with Monteggia injuries are to recognize the injury and to treat the injury by obtaining a straight and length-stable ulna and concentric reduction of the radial head. If closed reduction of the ulna and radial head is not possible, then open reduction and fixation of the ulna and open reduction of the radial head to remove any interposed soft tissue may be needed. In summary, to detect a Monteggia injury, radiographs of the forearm and elbow are needed. If a radial head dislocation is suspected and no obvious ulnar fracture is seen, an ulnar bow sign should be sought to confirm a traumatic etiology as opposed to a congenital etiology.

Entrapped Medial Epicondyle Fracture

Medial epicondyle fractures occur most commonly in older children 10 to 14 years of age.[17] Approximately 50% of medial epicondyle fractures are associated with elbow dislocations, and entrapment of the fragment is not possible without a dislocation.[32] Ulnar nerve injury may also occur with this injury, making a careful neurologic examination and early diagnosis essential.[18] While treatment of medial epicondyle fractures is controversial, an entrapped fragment is an absolute indication for operative intervention[17] as the joint will almost always remain subluxated due to the large fragment and its soft

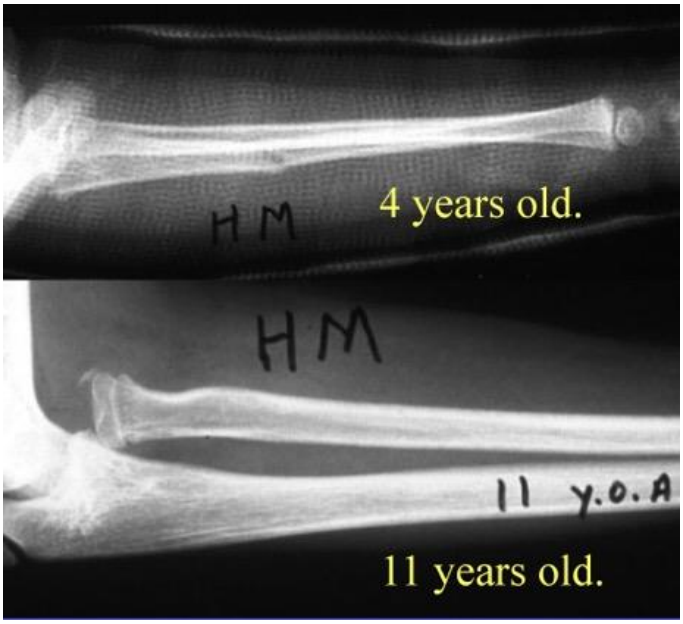
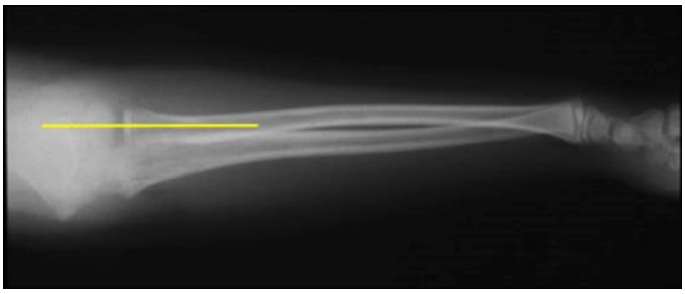


Figure 4. *This four year old with an ulna fracture had post-reduction radiographs that were supported by the providers hand. Unfortunately, the thumb obscured the elbow pathology that presented 7 years later.*



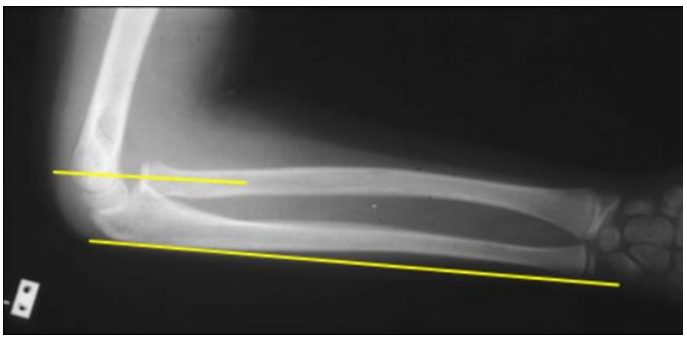


Figure 5a. *Anteroposterior radiograph of the forearm with an intact radiocapitellar alignment.*
Figure 5b. *Lateral radiograph of elbow with a displaced radial head noted by disruption of the radiocapitellar line. A positive "ulnar bow sign" is noted, suggesting a traumatic etiology for the displaced radial head.*

tissue attachments.[18] Smaller fragments, however, may result in less obvious displacement of the ulna-humeral joint (Figure 6).

On an AP radiograph, the distal humeral epiphysis may overlap the entrapped medial epicondyle, or the entrapped fragment can be confused for an ossification center of the trochlea.[18] It can be especially difficult to recognize an incarcerated fragment when there is only a small "fleck " of bone or if it is misinterpreted as the rare medial condyle fracture[4] (Figure 7). If the medial epicondyle can be seen on a lateral radiograph of the elbow with widening of the joint, it can be assumed that it is entrapped within the elbow joint.[33] Extraction by various maneuvers has been described, but most often, open reduction and screw fixation followed by early motion are recommended.

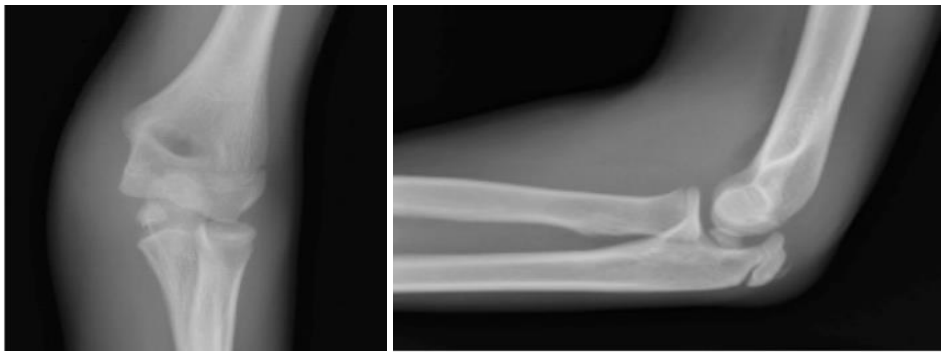


Figure 6a. *Anteroposterior radiograph of a 12-year-old male who sustained an elbow dislocation while wrestling.* ***Figure 6b.*** *Lateral radiograph of the elbow with entrapped medial epicondyle.*

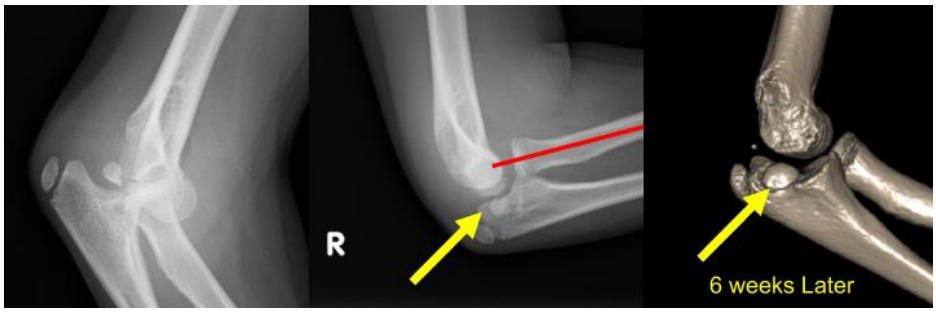


Figure 7. *This 12-year-old gymnast dislocated her elbow after a fall. Closed reduction was "uneventful;" in retrospect, the medial epicondyle (yellow arrow) was likely in the joint with slight displacement of the radiocapitellar joint (red line). Six weeks later, her treating orthopaedist got a CT scan for severe elbow pain and ulna nerve paresthesias and confirmed the missed entrapped epicondyle fracture.*

Hip Dislocation with Incongruous Joint After Reduction

Traumatic hip dislocation in pediatric patients is uncommon.[18,34] Low energy trauma can cause hip dislocation in a young patient due to pliable immature cartilage;[18] a higher energy force is generally required to cause a hip dislocation in an adolescent.[12] Multiple studies have focused on hip dislocation in adults and the importance of a post-reduction CT scan to evaluate joint congruity from intra-articular bony fragments not seen on plain radiographs. Guidelines for post-reduction imaging after hip dislocations in pediatric patients are not as well defined, in large part because of concerns about radiation from CT scans. Although closed reduction usually can be easily performed in children under 10 years of age, cartilage, labrum, or ligamentous or capsular interposition may prevent congruous reduction.[10,12,13,16,35] Because these structures are radiolucent, diagnosis be difficult via CT.

Figure 8. *Anteroposterior radiograph of the pelvis of a 10-year-old female after hip reduction following a fall.[12] There is joint asymmetry and medial joint space widening of the left hip joint, as well as a break in Shenton's line.*

After closed reduction of a hip dislocation, the post-reduction pelvic radiographs should be scrutinized carefully for any joint widening or asymmetry. The only evidence of interposition within the joint may be mild joint space widening, and up to 3mm of hip joint asymmetry may result from joint laxity or hematoma.[13,16,35] A break in Shenton's line can also herald an incongruous reduction[18] (Figure 8).

Any asymmetric joint widening seen on post-reduction hip radiographs should warrant advanced imaging. While CT scans readily identify intra-articular entrapment of osteochondral fragments, an MRI may be superior to CT scan for evaluating soft-tissue interposition such as capsule or labrum.[36] In patients younger than 13 years, the cartilaginous posterior acetabular wall is incompletely ossified and may not be fully appreciated on a radiograph or CT scan.[37] On CT, a posterior wall "fleck" sign, described by Blanchard et al., should raise suspicion of avulsion of the posterior labrum and tissue interposition[38] (Figure 9).

A post-reduction MRI also adds value by revealing the likely direction of the initial dislocation and guiding the best route for surgery to repair defects to the joint capsule without causing further insult to the joint. As such, posterior dislocations should be approached posteriorly, and an anterior dislocation should be approached anteriorly to preserve vascularity at risk from a posterior approach.

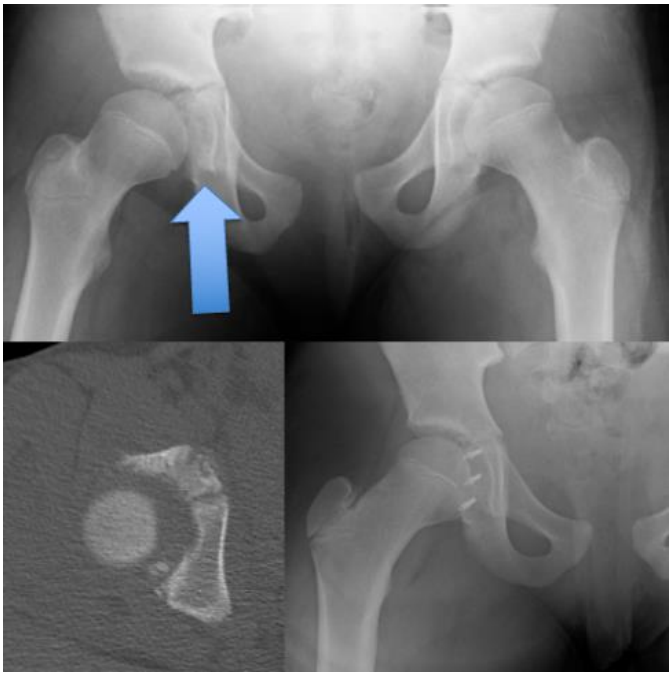


Figure 9. *This wrestler had a dislocated hip that was reduced. A post-reduction radiograph demonstrated joint widening (Blue arrow). The CT scan showed a "fleck" of bone that was attached to a large labral injury that required ORIF.*

Ipsilateral Extremity Fractures

In the setting of a displaced fracture, a second ipsilateral injury can be easily missed. In our experience, an example of a RAMBO lesion is a tibial shaft fracture with concurrent distal tibia fracture (Figure 10). This fracture pattern is different from an adult tibial fracture, where the proximal fracture line usually extends distally to the ankle joint. In one recent pediatric study, 4.3% of tibial shaft fractures had a concurrent fracture in the distal tibia, and 36% of these second fractures were originally undetected.[39] High- and low-energy mechanisms may result in a secondary distal tibial fracture.[41] Transitional fractures, such as triplane and Tillaux fractures, are the most common second fractures.[41] If an oblique or spiral fracture is present at the junction of the middle and distal thirds of the tibia, ankle-specific imaging is recommended.[39] In addition, older age in one study (12.7 years vs. 11 years) was a patient characteristic significantly associated with secondary distal tibial fractures.[41]

Ankle-specific imaging aids in ruling out a secondary fracture associated with a tibial shaft fracture, but sometimes these anomalies are not visible on radiographs (Figure 10). A high clinical suspicion and careful examination of the ankle for swelling and bruising are necessary and may prompt advanced imaging. A CT scan can help identify fractures when there is an appropriate index of suspicion, but radiation to the pediatric patient is always a consideration. In summary, older children (10-13 years) with a tibial shaft fracture at the junction of the middle and distal third can be associated with a second transitional type distal tibial fracture. Ankle-specific

Figure 10a, b (left). *Anteroposterior and lateral radiographs of right tibia of 11-year-old female after a fall. There is an obvious tibial shaft fracture and no additional fracture is seen.*
Figure 10c, d, e (above). *A CT scan of ankle shows an intra-articular fracture.*

imaging, possible advanced imaging, and careful examination are necessary to rule out an ipsilateral second fracture.

Summary

Radiographic anomalies missed by orthopaedists, or RAMBO lesions, are traumatic pediatric secondary injuries with potential clinical significance. Each of the five lesions presented here can have a subtlety that can be missed if careful scrutiny of the radiographs and a thorough clinical examination and history are not performed. These cases complement other orthopaedic literature on specific missed injuries,[5,10, 12, 28, 30] such as upper extremity "TRASH" lesions.[4] A high clinical suspicion and thorough physical examination remain the most important tools for preventing radiographic anomalies missed by orthopaedists.

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