SA–CME Information

Elbow Effusion: Utility and Limitations of Radiography in Pediatric Injuries

Description

Fractures of the elbow are one of the commonest pediatric injuries. Some of these fractures can be occult on initial radiographs, an elbow effusion being the only initial finding. Elbow effusion can be detected on an adequately obtained lateral radiographic projection of the elbow by identifying the visibility and shape of the anterior and posterior fat pads. To maximize the accuracy of detecting elbow effusions, radiologists should be aware of conditions that can affect the visibility of these fat pads.

Learning Objectives

Upon completing this activity, the reader should be able to:

- Identify normal location, visibility and shape of the anterior and posterior fat pads of the elbow;
- Recognize changes in the anterior and posterior fat pads of the elbow due to joint effusion; and,
- Explain the conditions that can lead to false-positive and false-negative diagnoses of elbow effusion on radiographs in the pediatric population.

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Target Audience

- Radiologists
- Related Imaging Professionals

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Elbow Effusion: Utility and Limitations of Radiography in Pediatric Injuries

Sachin S Kumbhar, MD

Elbow fractures are common in children and can be extremely subtle on radiographs.[1] Most are associated with joint effusion,[2] which may suggest occult fracture where none is visible.[3-5] Fortunately, effusions can be detected at radiography, the imaging procedure most commonly used to diagnose elbow injuries.

This review article discusses the evidence linking elbow effusion with occult fractures. It also covers the anatomic basis of the fat-pad signs used to diagnose an elbow effusion. Finally, this article reviews the factors and circumstances that can lead to false-positive and false-negative diagnoses of elbow effusions.

Variable Evidence of Predictive Values

Different authors report varying positive predictive values of elbow effusion in the diagnosis of occult elbow fractures. Donnelly, et al, reviewed the follow-up radiographs of 54 children with a history of trauma and elbow effusion without visible fractures on initial radiographs. Nine patients (17%) developed signs of fracture healing, indicating an occult fracture.[6] Al-Aubaidi, et al, performed MRI scans in 24 children with effusion and found a fracture in 6 (23%) of these patients.[7]

In contrast, Skaggs, et al, found an occult fracture in the radiographs of 34 of 45 (76%) children.[5] Using follow-up MRI, Major, et al, and Pudas, et al, reported occult fractures in 57% and 89% children, respectively.[3,4] Despite the wide variation of these results, it is clear that not all children with effusion on initial presentation have an occult fracture. Most authors also agree that the presence of effusion provides evidence of significant injury and that these children should at least be splinted and clinically followed.[8]

Radiographic Diagnosis

Al-Aubaidi, et al, found that 5 of the 31 patients in their study were reported to have a positive fat pad sign on their initial radiograph but were deemed to have normal radiographs on subsequent expert review.[7] In our experience, inaccurate interpretation of the elbow fat pads is not uncommon and can lead to either a false positive or a false negative diagnosis of elbow effusion. Accurate interpretation of the fat pads requires an understanding of elbow anatomy and optimal positioning for lateral radiographs.

The anterior and posterior fat pads are intracapsular, extrasynovial structures.[9] Both the anterior and posterior fat pads are readily visible on CT (Figure 1). The posterior fat pad lies deep within the olecranon fossa and is flanked by bone on three sides. A lateral radiograph in this circumstance would render the posterior fat pad invisible, as it would be obscured by the medial and lateral osseous structures. In contrast, the anterior fat pad is not flanked by bone laterally or medially. Hence, on lateral radiographs the anterior fat pad is normally visible abutting the distal humerus anteriorly (Figure 2).

In elbow effusion, the posterior fat pad is displaced dorsally and superiorly by the joint fluid. Thus, bone does not flank the posterior fat pad medially and/or laterally, and it becomes visible on the lateral radiograph (Figure 3). Effusion also displaces the anterior fat pad anteriorly and superiorly. The anterior fat pad, which is normally visible on the lateral radiograph, loses its normal "teardrop' shape and develops a "sail" shape with a concave inferior

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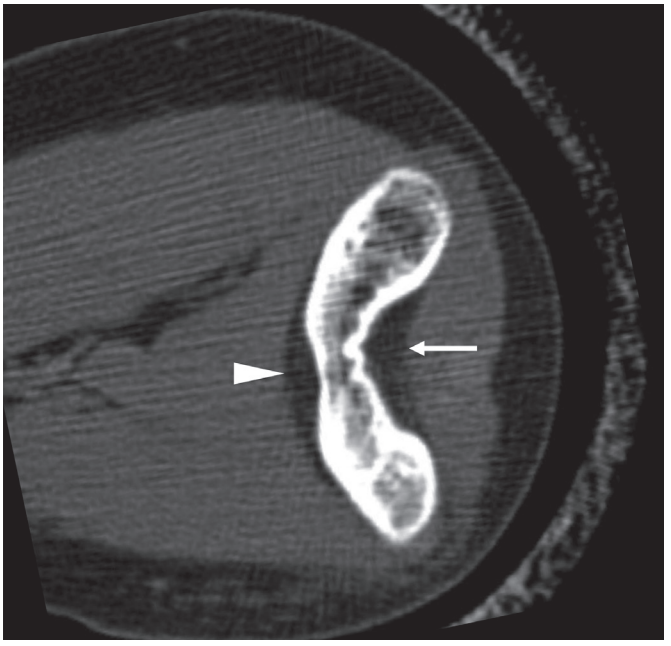

FIGURE 1. *Normal anatomy of the distal humerus in a 12-year-old. Axial CT image demonstrates the posterior fat pad (arrow) within the olecranon fossa flanked by bone on the medial and lateral sides. The anterior fat pad (arrowhead) does not have bone either medially or laterally.*

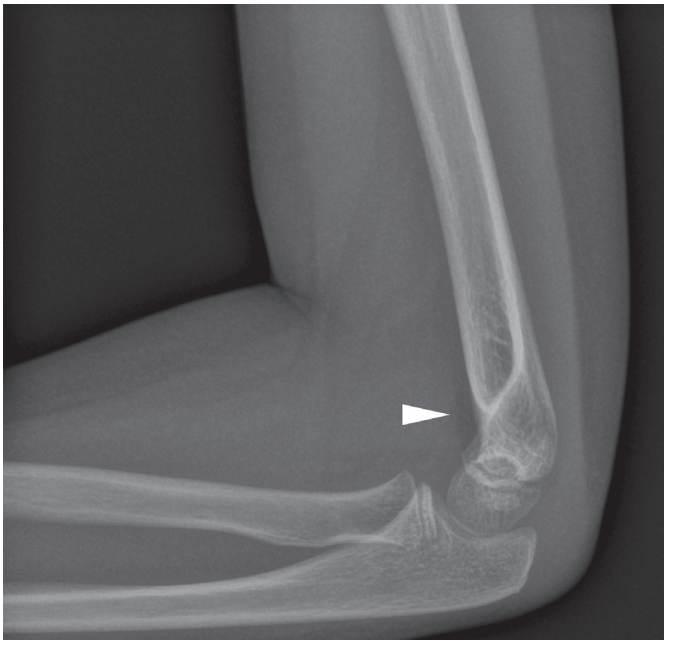

FIGURE 2. *Normal radiograph of the elbow in an 8-year-old. Lateral radiograph demonstrates the normal teardrop shape of the anterior fat pad (arrowhead) abutting the distal humerus. Note that the posterior fat pad is normally not seen.*

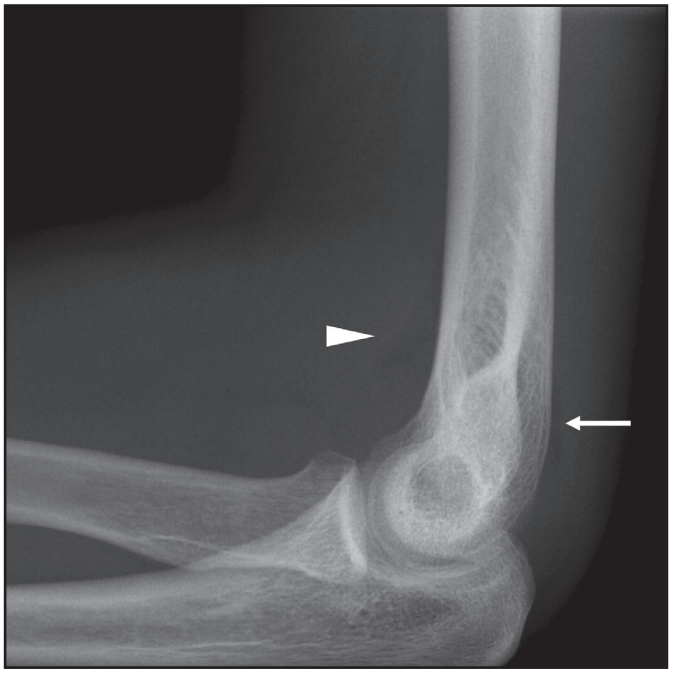

FIGURE 3. *Elbow effusion in an 18-year-old. Lateral radiograph demonstrates an elevated, sail-shaped anterior fat pad (arrowhead) and an elevated posterior fat pad (arrow).*

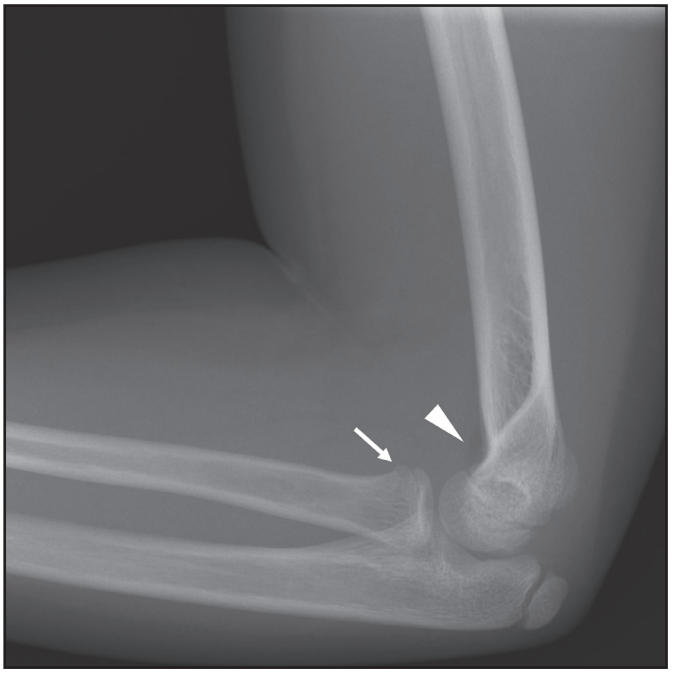

FIGURE 4. *Radius neck fracture in 10-year-old. Lateral radiograph demonstrates a nondisplaced fracture (arrow) of the neck of the radius. Note that the anterior fat pad (arrowhead) is not elevated and the posterior fat pad is not visible.*

margin as it is lifted off the humerus by the joint fluid (Figure 3). Al-Aubaidi, et al, found the anterior fat pad to be more sensitive than the posterior fat pad in detecting effusion, while finding the posterior fat pad to be more specific for underlying osseous injury.[7] The negative predictive value of a normal anterior fat pad in ruling out fracture has been reported to be as high as 98.2% in a study of 197 patients with elbow trauma.[10]

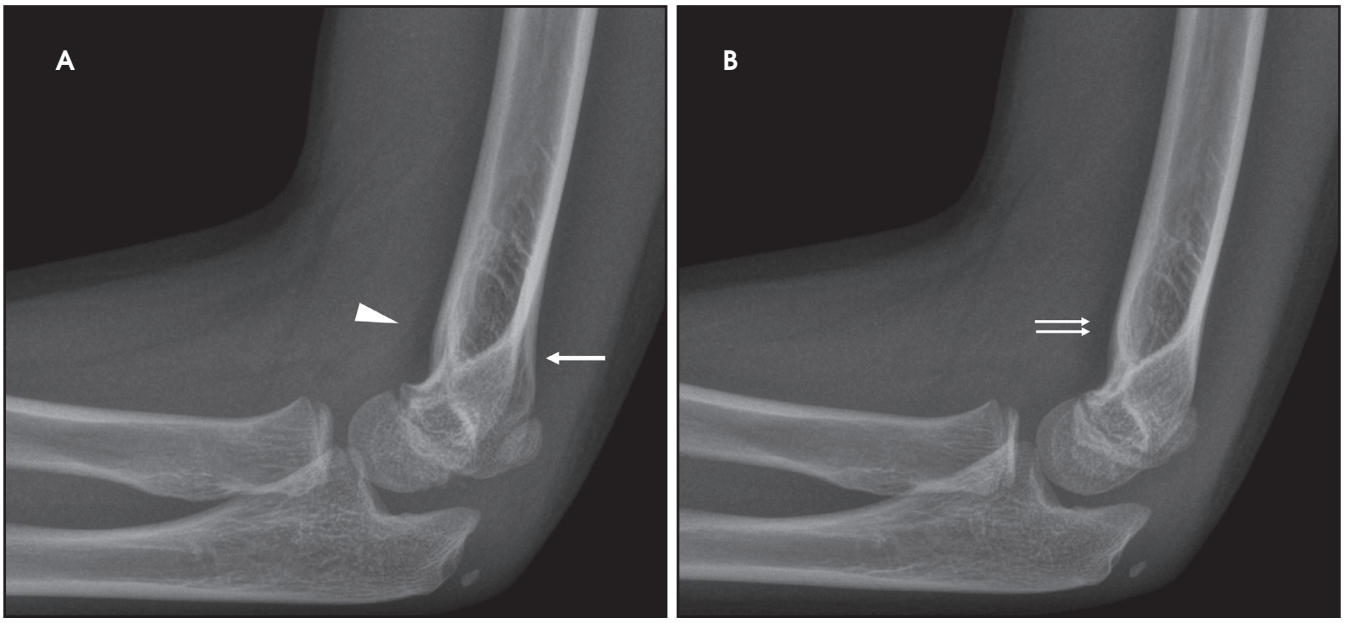

FIGURE 5. *Effect of radiographic positioning on the normal anterior fat pad in an 8-year-old. (A) Lateral radiograph demonstrates a triangular anterior fat pad (arrowhead), which can look like the sail shape of an elevated anterior fat pad. Note that the posterior supracondylar ridges (arrow) do not overlap, indicating suboptimal radiographic positioning. (B) Repeat radiograph obtained with proper positioning demonstrates a normal teardrop-shaped anterior fat pad (double arrow) and overlap of the supracondylar ridges. The posterior fat pad is not visible.*

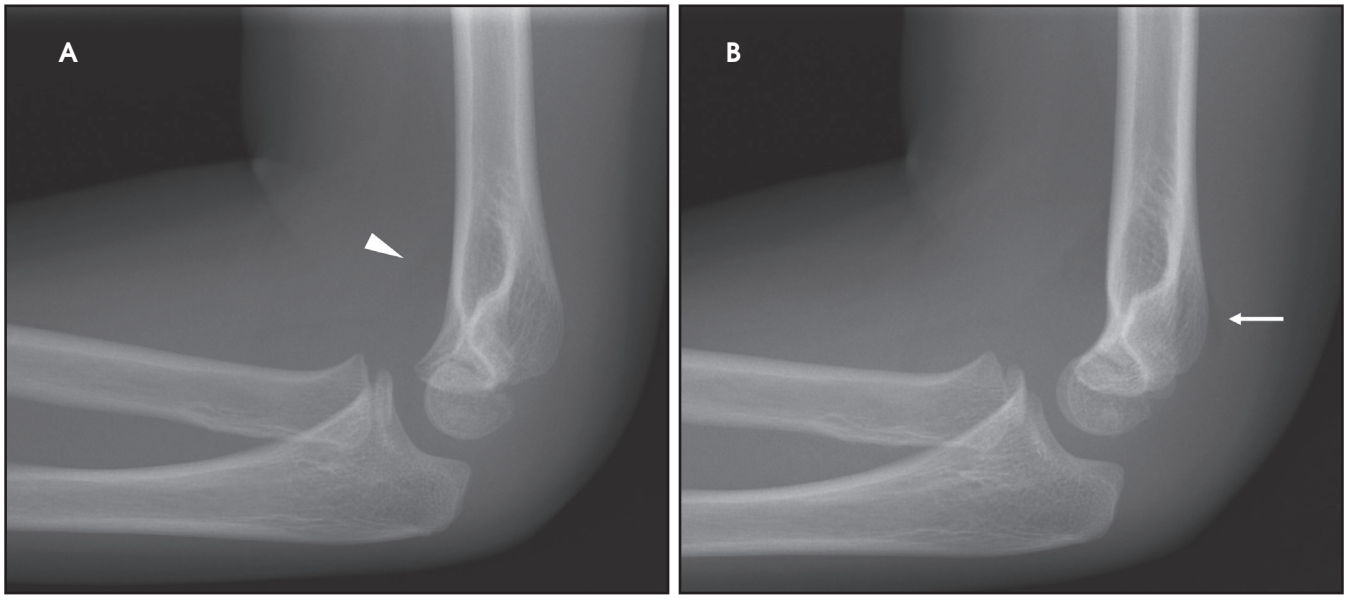

FIGURE 6. *Effect of radiographic positioning on an elevated posterior fat pad in a 7-year-old. (A) Lateral radiograph demonstrates an elevated anterior fat pad (arrowhead). Note that the posterior supracondylar ridges do not overlap, indicating suboptimal positioning. The posterior fat pad is not visible. (B) Repeat lateral radiograph obtained a few minutes later demonstrates better alignment of the supracondylar ridges. An elevated posterior fat pad (arrow) is now visible.*

Limitations of Radiography

Elbow joint effusion is commonly seen in intra-articular fractures.[2] The capsule of the elbow joint attaches to the margins of the trochlea and capitellum, the coronoid process, and the neck of the radius. The olecranon fossa, radiocapitellar joint, ulnotrochlear joint and the proximal radioulnar joint are intracapsular.[11] Most fractures involving the intra-articular osseous structures will lead to joint effusion.[2] However, intra-articular fractures can be present without joint effusion, with radius neck fractures being the most common such fracture (Figure 4).[2] This is because only a small portion of the radius neck is intra-capsular.

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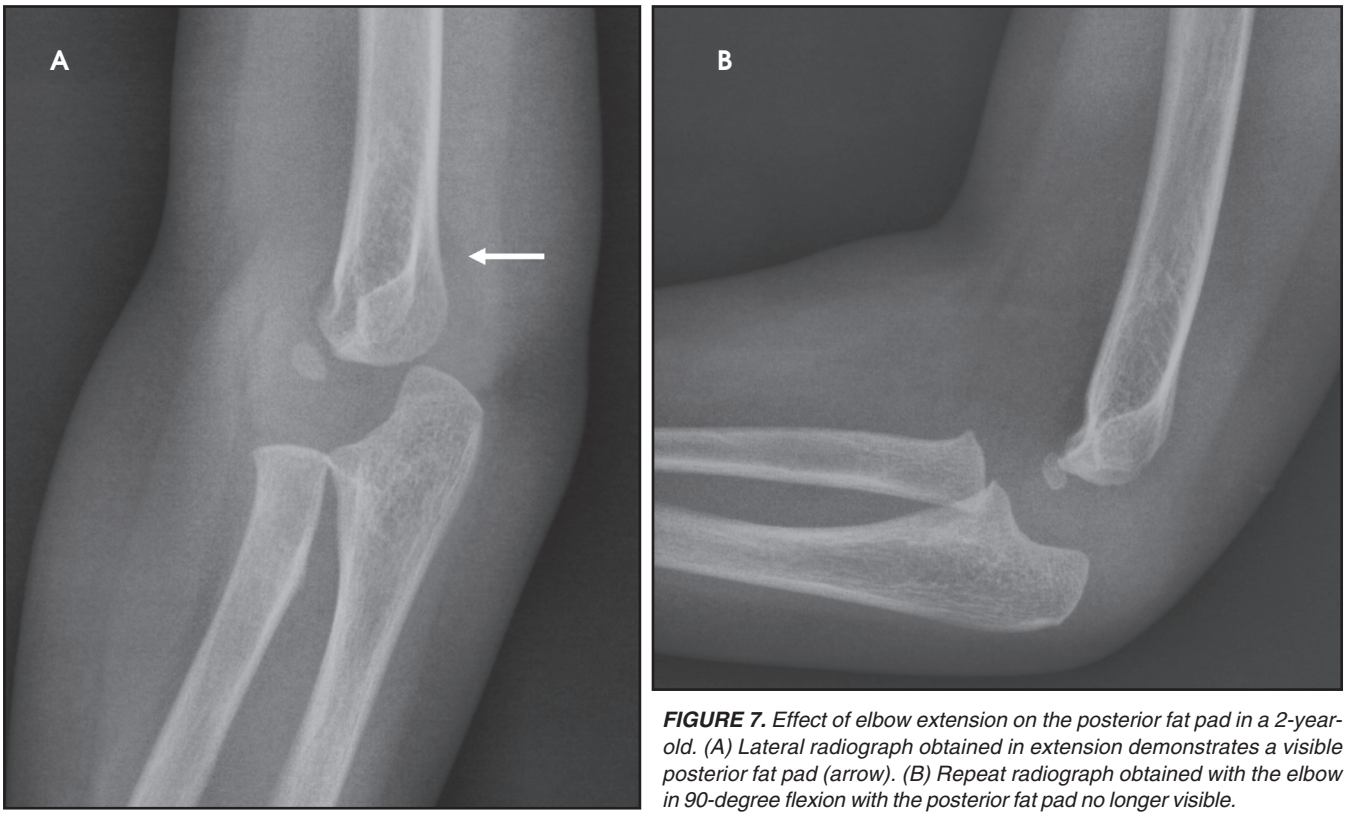

FIGURE 7. *Effect of elbow extension on the posterior fat pad in a 2-year-old. (A) Lateral radiograph obtained in extension demonstrates a visible posterior fat pad (arrow). (B) Repeat radiograph obtained with the elbow in 90-degree flexion with the posterior fat pad no longer visible.*

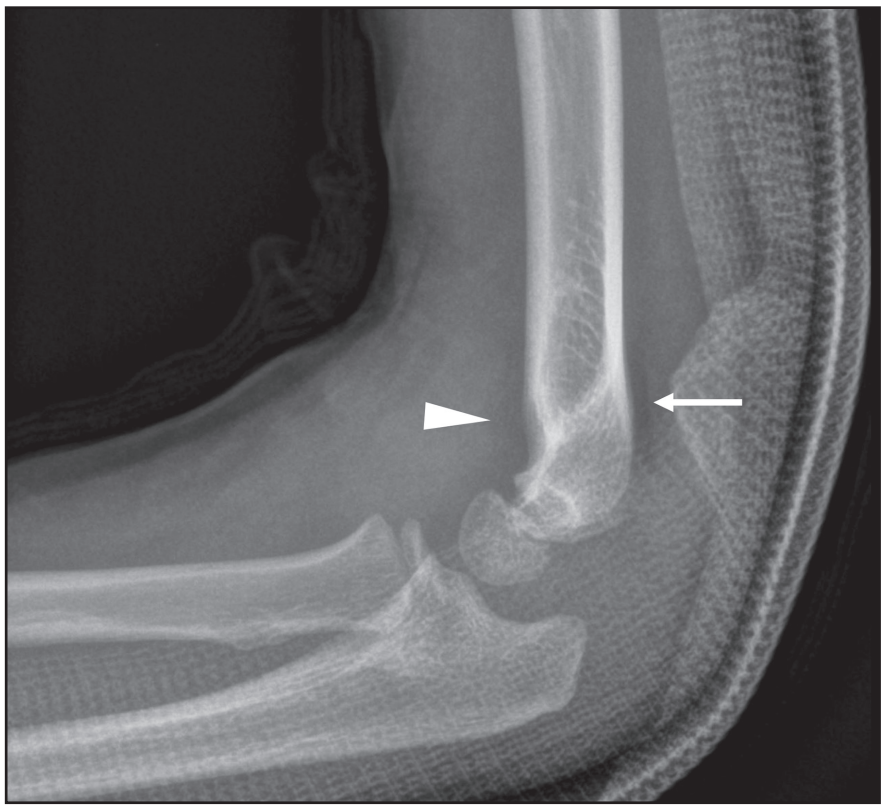

FIGURE 8. *Small elbow effusion in a 6-year-old. Lateral radiograph demonstrates elevated posterior fat pad (arrow). The anterior fat pad is normal (arrowhead).*

Fractures involving the bone outside of the capsular attachments, such as avulsion fractures of the medial epicondyle, will not result in an elbow effusion.[12] Optimal radiographic technique in obtaining the lateral view of the elbow is important to accurately assessing the fat pads.[13] Superimposition of the medial and lateral supracondylar ridges of the distal humerus is a reliable indicator of an adequate lateral radiograph.[14] Suboptimal lateral projection can lead to a false-positive or false-negative diagnosis of effusion.[13]

If the lateral projection is not a true lateral, the anterior fat pad may not appear teardrop shaped, but instead may be appear sail-like, leading to a false-positive diagnosis (Figure 5). Conversely, a suboptimal lateral view may lead to obscuring of the posterior fat pad by the medial or lateral supracondylar ridge, leading to a false-negative assessment, even in the presence of an effusion and a potentially elevated posterior fat pad (Figure 6).[13] Positioning the upper arm, elbow, and forearm

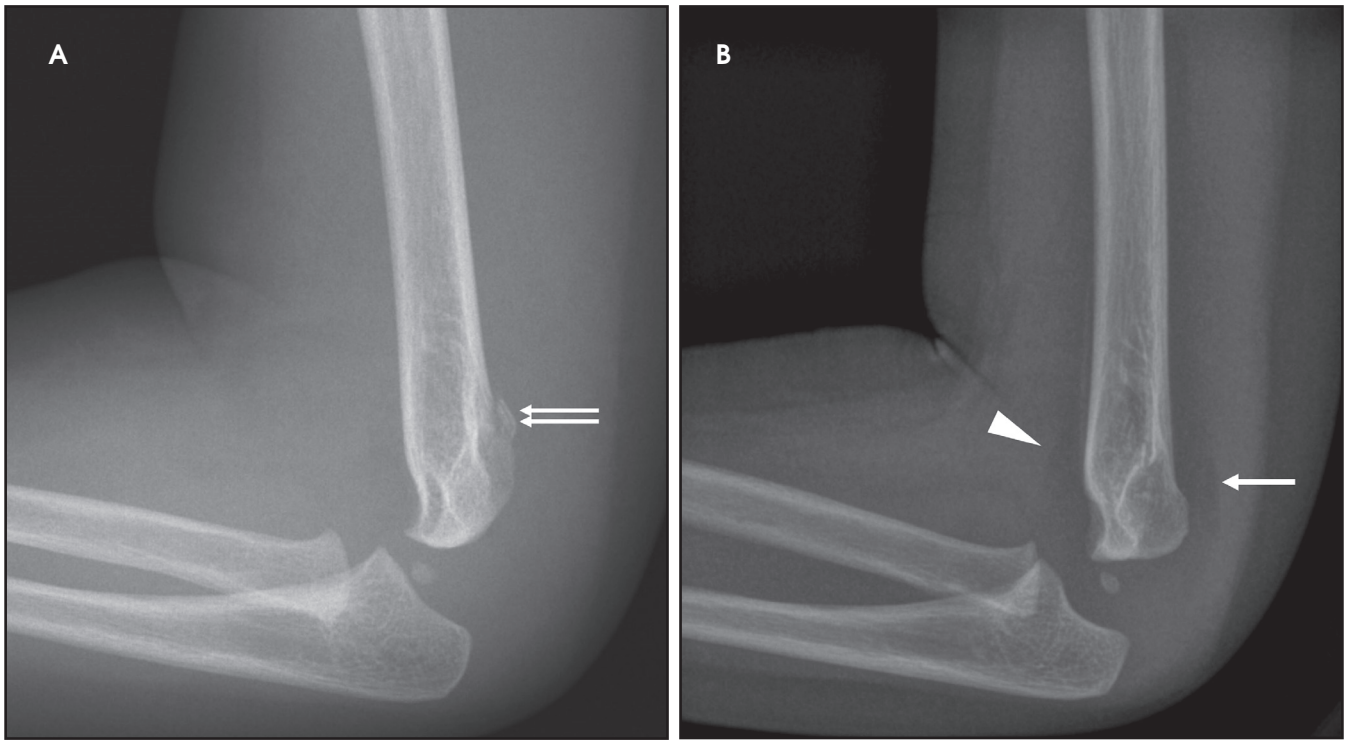

FIGURE 9. *Large elbow effusion in a 2-year-old. (A) Lateral radiograph demonstrates a supracondylar fracture (double arrows). The anterior and posterior fat pads are not visible. (B) Follow-up lateral radiographs demonstrate elevated anterior (arrowhead) and posterior (arrow) fat pads now visible owing to a decrease in effusion.*

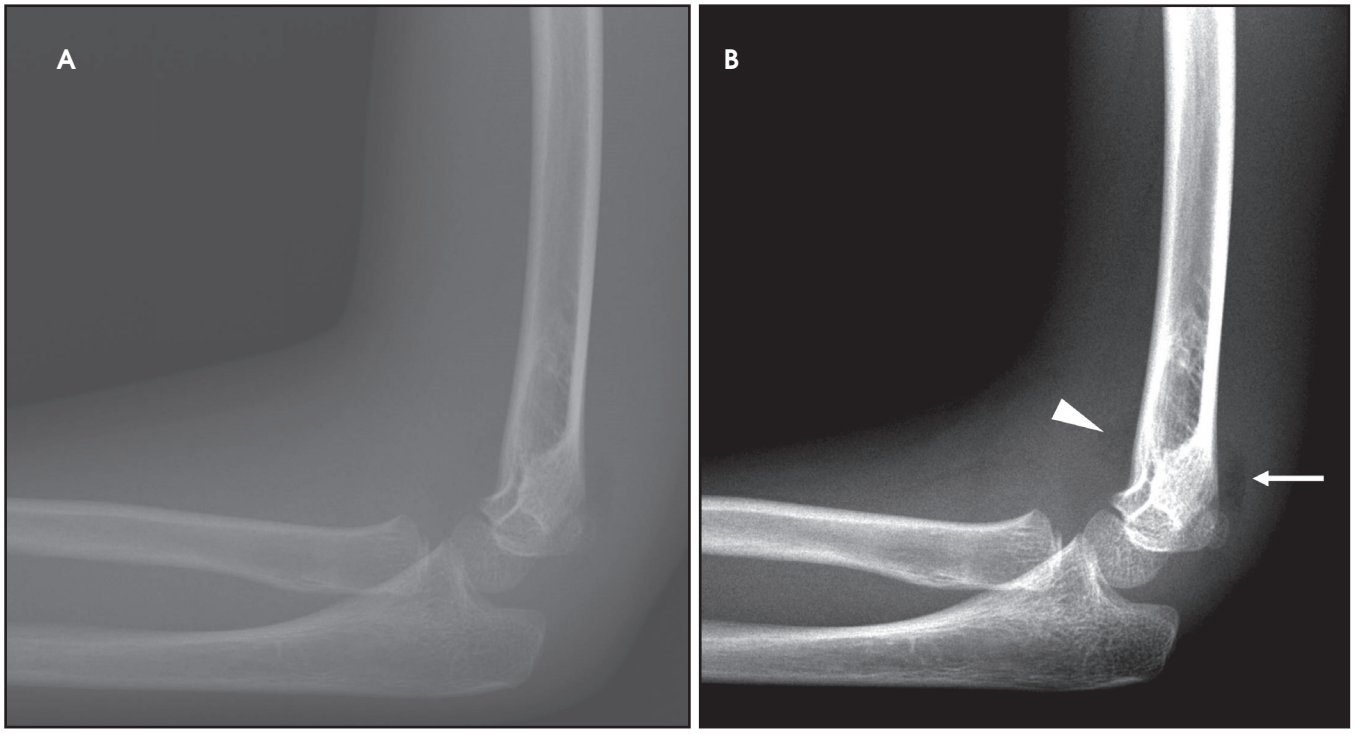

FIGURE 10. *Effect on window width and level on the visibility of the fat pads in a 5-year-old. (A) Lateral radiograph with suboptimal windowing demonstrates difficulty identifying the anterior and posterior fat pads. (B) Same radiograph viewed with a different window width and level demonstrates clear visibility of the anterior (arrowhead) and posterior (arrow) fat pads. Differences in radiographic exposure can have similar effects on fat-pad visibility.*

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flat on the table during acquisition helps to improve lateral radiograph quality. Adjusting the table or patient-seat height, with the patient's thumb pointing upward, can help achieve this position. Optimal positioning can also be achieved with the "standing salute" and 90-degree abduction at the shoulder and 90-degree flexion at the elbow.[15] The posterior fat pad may be normally visible by obtaining the lateral radiograph in extension, as the olecranon process displaces the fat pad outward in this position (Figure 7).[9]

Effusion size also matters with respect to diagnosing elbow effusion from radiographs. A small effusion may elevate only the posterior fat pad, with the anterior fat pad appearing normal (Figure 8).[9] At the other end of the spectrum, a very large effusion may efface both the anterior and the posterior fat pads, rendering them invisible on radiographs (Figure 9). Complete lack of visibility of the anterior fat pad may be a clue to the presence of a large effusion in this situation.

A traumatic rupture of the elbow joint capsule may lead to a false-negative fat pad sign, as the capsular tear would allow joint fluid extravasation into the surrounding tissues.[16]

It is also worth emphasizing that radiographic exposure in the lateral view should be sufficient to differentiate fat from soft-tissue density. An underexposed radiograph may not demonstrate abnormal fat pads even if elbow effusion is present. Similarly, radiologists should be sure to adjust the window width and level while evaluating for elbow effusion, as fat and soft-tissue contrast may not be visible at the default window setting (Figure 10).

Conclusion

Elbow effusion on radiographs may be the only indication of occult fracture in children. Several factors can cause false-positive or false-negative diagnoses of elbow effusion, and knowing these pitfalls is essential to accurately interpret pediatric elbow radiographs.

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