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# Clinical accuracy of the posterior fat pad sign for detecting elbow fractures in children

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## ABSTRACT

**Aims:** To assess the diagnostic accuracy of the posterior fat pad sign (PFPS) on lateral elbow radiographs in identifying fractures in pediatric patients with acute elbow trauma, and to evaluate whether angle measurement of PFPS enhances diagnostic performance.

**Methods:** This retrospective study included patients under 18 years who presented with elbow trauma to a tertiary emergency department between January 2022 and January 2025. All patients underwent lateral elbow radiography followed by computed tomography (CT), which served as the reference standard. The presence of PFPS and the angle between the posterior fat pad and humeral shaft were independently assessed by two emergency physicians blinded to CT findings. Diagnostic metrics—including sensitivity, specificity, likelihood ratios, and misclassification rates—were calculated for both visual PFPS presence and angle-based assessment.

**Results:** Of the 213 patients included, 65.3% had CT-confirmed elbow fractures. PFPS was present in 66.2% of cases and demonstrated a sensitivity of 62.2% and specificity of 81.3% for predicting fractures. The optimal PFPS angle cutoff was 16.5°, which yielded a sensitivity of 81.3% and specificity of 62.2%.

**Conclusion:** PFPS is a reliable radiographic indicator of pediatric elbow fractures. Quantitative angle measurement improves diagnostic accuracy and may support more consistent decision-making in emergency settings where radiographic findings are ambiguous.

**Keywords:** Posterior fat pad sign, pediatric elbow fracture, diagnostic accuracy

## INTRODUCTION

Elbow trauma is a common cause of emergency department visits among children, often resulting from low-energy falls or sports-related injuries. While many of these injuries are minor, a significant proportion involves occult or radiographically subtle fractures, especially in younger children whose epiphyseal anatomy is still developing. Supracondylar and radial neck fractures, in particular, may not be visible on initial X-rays, making clinical and radiologic correlation essential for timely diagnosis and appropriate management.[1-3]

The posterior fat pad sign (PFPS) is a widely recognized indirect radiographic indicator of intra-articular effusion, often suggesting the presence of an occult fracture when no cortical disruption is visible. In pediatric elbow injuries, PFPS has been associated with both supracondylar and radial head fractures, and its diagnostic value continues to be the subject of clinical scrutiny. Recent investigations have emphasized the importance of observer reliability and imaging quality in interpreting the PFPS, with varying reports of its sensitivity and specificity depending on methodology and patient selection.[4-7] In addition, studies have explored the use of adjunct modalities such as ultrasonography and digital tomosynthesis to complement traditional radiography, particularly in ambiguous cases.[8-10]

This study aims to evaluate the diagnostic accuracy of the PFPS in identifying elbow fractures confirmed by computed tomography (CT) in children with acute elbow trauma.

## METHODS

This retrospective diagnostic accuracy study was conducted in the emergency department of a tertiary care hospital. The study included patients under the age of 18 who presented with acute elbow trauma between January 1, 2022, and January 1, 2025. Approval was obtained from the Ethics Committee of İstanbul Yeni Yüzyıl University (Date: 07.05.2025, Decision No: 2025/05-1541), and all procedures were performed in accordance with the Declaration of Helsinki.

Patients were eligible if they were younger than 18 years, presented to the emergency department with blunt elbow

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trauma, underwent lateral elbow radiography at the time of admission, and subsequently received a CT scan for diagnostic confirmation. Patients were excluded if initial imaging was unavailable, if there was evidence of open fractures or dislocations on presentation, or if CT was not performed within 24 hours of admission.

Radiographs were retrospectively reviewed by two emergency physicians blinded to CT findings. The presence or absence of a PFPS was recorded for each case. As part of the radiographic assessment protocol, the presence of the PFPS was visually identified on lateral elbow radiographs. A representative image from the study cohort is provided to illustrate the diagnostic criteria used (**Figure 1**). Lateral X-ray of the left elbow demonstrating the "anterior fat pad sign" and "PFPS." The anterior fat pad, normally visible and seen here elevated and displaced anteriorly, suggests joint effusion. The posterior fat pad, which is not typically visualized on normal radiographs, is visible and displaced posteriorly, indicating an occult intra-articular fracture—most commonly a supracondylar fracture in pediatric patients or a radial head fracture in adults. For patients with a visible PFPS, the angle between the humeral shaft and the posterior fat pad was measured using standardized DICOM viewing software. CT images were independently evaluated by a board-certified radiologist to confirm the presence or absence of elbow fractures, which served as the reference standard. The primary outcome of the study was the diagnostic performance of PFPS—presence versus absence—in predicting CT-confirmed elbow fractures.

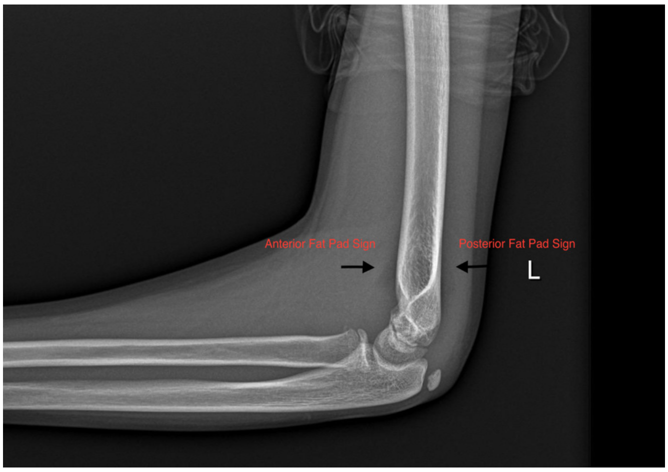


**Figure 1.** Lateral elbow radiograph illustrating elevated anterior and visible posterior fat pad signs, indicative of joint effusion and possible occult fracture

## Statistical Analysis

The data analyses were performed using R version 4.4.2. Descriptive statistics were presented as frequencies and percentages for categorical variables and as median [interquartile range (IQR)] for non-normally distributed continuous variables. Normality was assessed visually using histograms and Q–Q plots, and numerically with the Shapiro–Wilk test and skewness statistics. Diagnostic performance metrics of PFPS presence for predicting elbow fractures confirmed by CT were calculated, including sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), positive likelihood ratio (+LR), negative likelihood ratio (–LR), and the Youden index. A 95% confidence interval (CI) was reported for all estimates, where applicable, using the Wilson method. Receiver operating characteristic (ROC) curve analysis was performed for PFPS angle, with the area under the curve (AUC) and 95% CI calculated using the DeLong method. The optimal PFPS angle cutoff was determined by maximizing the Youden index. Diagnostic metrics at this cutoff, including sensitivity, specificity, +LR, and –LR, were also calculated, with 95% CIs derived using the Katz method for likelihood ratios. False discovery rate (FDR) and false omission rate (FOR) were calculated both at the observed prevalence and modeled across a range of hypothetical disease prevalence levels (5% to 95%) to provide a clinical misclassification profile of PFPS. FDR and FOR curves were plotted accordingly. All statistical tests were two-sided, and p-values <0.05 were considered statistically significant.

# RESULTS

A total of 213 patients with elbow trauma were included in the study (**Figure 2**). The median age of the cohort was 10 years [interquartile range (IQR) 7–12], and 45.1% were male. Right-sided injuries were more common (55.9%), and the dominant arm was involved in 48.8% of cases. The most frequent mechanism of injury was fall from standing height (37.6%), followed by fall from height (25.4%). Swelling, tenderness, and limited range of motion were observed in 81.7%, 79.8%, and 78.9% of the patients, respectively. PFPS was present in 66.2% of cases (**Table 1**).

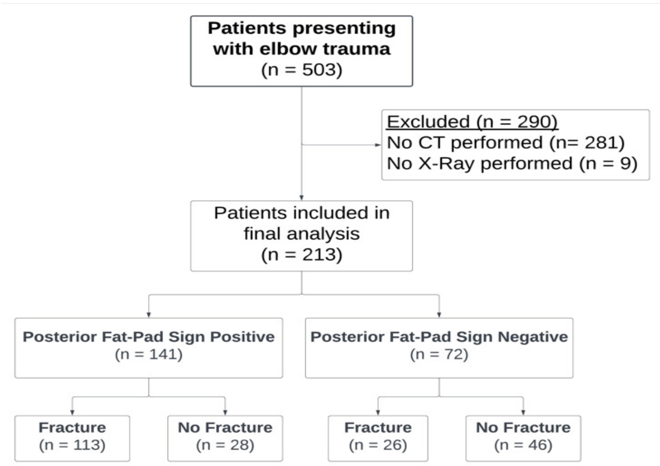


**Figure 2.** Patient flowchart

CT confirmed elbow fracture in 139 patients (65.3%), with supracondylar fractures being the most prevalent subtype (33.8%). Among those with fractures, 40.4% had displaced fractures (≥2 mm). Metaphyseal and intra-articular locations were the most frequent fracture sites. The majority of CT scans were performed due to clinical suspicion (45.1%) or protocol-based indications (28.6%). Hospital admission was required in 28.2% of the cohort, and 21.1% underwent surgical intervention (**Table 2**).

In the diagnostic performance analysis, PFPS presence demonstrated a sensitivity of 0.622 (95% CI: 0.501–0.732) and a specificity of 0.813 (95% CI: 0.738–0.874) for predicting

**Table 1.** Baseline demographic and clinical characteristics of included patients

| Variable | Subcategory | (n=213) | %/[IQR] |
|---|---|---|---|
| Age (years), median [IQR] | | 10 | [7–12] |
| Sex | Male | 96 | 45.1% |
| Side of injury | Left | 94 | 44.1% |
| | Right | 119 | 55.9% |
| Dominant arm involved | Yes | 104 | 48.8% |
| Mechanism of injury | Fall from standing height | 80 | 37.6% |
| | Fall from height | 54 | 25.4% |
| | Direct blow | 8 | 3.8% |
| | Sports injury | 23 | 10.8% |
| | Motor vehicle accident | 14 | 6.6% |
| | Other | 34 | 16.0% |
| Swelling | Yes | 174 | 81.7% |
| Tenderness | Yes | 170 | 79.8% |
| Limited range of motion | Yes | 168 | 78.9% |
| Pain score (VAS), median [IQR] | | 7 | [6–8] |
| BMI (kg/m$^2$), median [IQR] | | 18.1 | [15.5–20.9] |
| PFPS present | | 141 | 66.2% |

BMI: Body-mass index, IQR: Interquartile range, PFPS: Posterior fat pad sign, VAS: Visual Analog Scale

**Table 2.** CT findings, management, and outcomes of included patients

| Variable | Subcategory | (n=213) | %/[IQR] |
|---|---|---|---|
| Fracture on CT | | 139 | 65.3% |
| Displaced fracture (≥2 mm) | | 86 | 40.4% |
| Fracture type | No fracture | 74 | 34.7% |
| | Supracondylar | 72 | 33.8% |
| | Radial head | 29 | 13.6% |
| | Olecranon | 6 | 2.8% |
| | Capitellum | 10 | 4.7% |
| | Coronoid process | 8 | 3.8% |
| | Monteggia variant | 7 | 3.3% |
| | Other | 7 | 3.3% |
| Fracture location | No fracture | 74 | 34.7% |
| | Metaphyseal | 47 | 22.1% |
| | Intra-articular | 77 | 36.2% |
| | Other | 15 | 7% |
| Reason for CT | Clinical suspicion | 96 | 45.1% |
| | Protocol-based | 61 | 28.6% |
| | Inconclusive X-ray | 39 | 18.3% |
| | Other | 17 | 8% |
| Hospital admission | | 60 | 28.2% |
| Surgical intervention | | 45 | 21.1% |
| Days until pain resolution, median [IQR] | | 12 | [6–15] |

CT: Computed tomography, IQR: Interquartile range

CT-confirmed elbow fractures. The PPV was 0.639 (95% CI: 0.517–0.749), and the NPV was 0.801 (95% CI: 0.726–0.864). The +LR was 3.323 (95% CI: 2.251–4.906), and the –LR was 0.465 (95% CI: 0.344–0.630). The Youden index was calculated as 0.435 (**Table 3**).

**Table 3.** Diagnostic performance of posterior fat pad sign for predicting elbow fractures confirmed by computed tomography

| Metric | Value | 95% CI |
|---|---|---|
| Sensitivity | 0.622 | 0.501-0.732 |
| Specificity | 0.813 | 0.738-0.874 |
| Positive predictive value | 0.639 | 0.517-0.749 |
| Negative predictive value | 0.801 | 0.726-0.864 |
| Positive likelihood ratio | 3.323 | 2.251-4.906 |
| Negative likelihood ratio | 0.465 | 0.344-0.630 |
| Youden index | 0.435 | - |

CI: Confidence interval

Analysis of PFPS angle yielded an AUC of 0.698 (95% CI: 0.621–0.775) (**Figure 3**). The optimal cutoff point was determined as 16.5°, providing a sensitivity of 0.813 and a specificity of 0.622 at this threshold. The corresponding +LR and –LR were 2.149 (95% CI: 1.587–2.908) and 0.301 (95% CI: 0.204–0.444), respectively (**Table 4**).

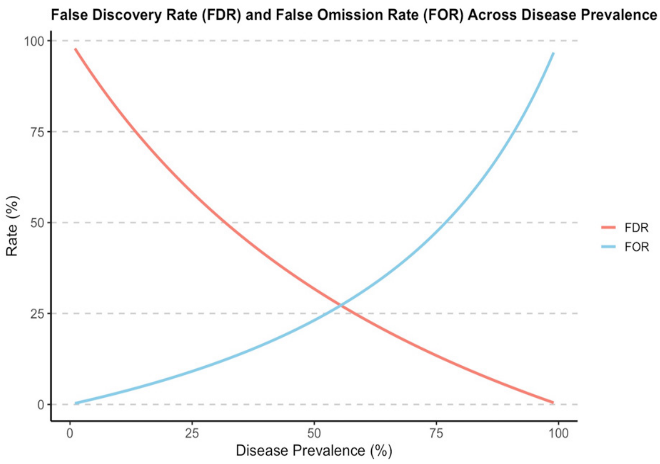


**Figure 3.** Receiver operating characteristic curve of posterior fat pad sign angle for predicting elbow fractures confirmed by computed tomography

**Table 4.** Diagnostic performance of posterior fat pad sign angle for predicting elbow fractures confirmed by computed tomography

| Metric | Value | 95% CI |
|---|---|---|
| Area under the curve | 0.698 | 0.621-0.775 |
| Optimal PFPS angle cutoff (°) | 16.5 | - |
| Sensitivity at cutoff | 0.813 | - |
| Specificity at cutoff | 0.622 | - |
| Positive likelihood ratio | 2.149 | 1.587-2.908 |
| Negative likelihood ratio | 0.301 | 0.204-0.444 |

The optimal cutoff was determined using the Youden index. Data are presented as point estimate and 95% confidence interval where applicable. CI: Confidence interval, PFPS: Posterior fat pad sign

Beyond conventional diagnostic performance metrics, FDR and FOR were analyzed across varying disease prevalence levels to assess the clinical misclassification profile of PFPS.

At a disease prevalence of 10%, FDR was 80.7%, decreasing progressively to 4.9% at 90% prevalence. Conversely, FOR increased from 3.2% at 10% prevalence to 73.0% at 90% prevalence (**Table 5, Figure 4**).

**Table 5.** False discovery and omission rates of posterior fat pad sign at varying disease prevalence levels for predicting elbow fractures confirmed by computed tomography

| Disease prevalence | FDR | FOR |
|---|---|---|
| 10% | 80.7% | 3.2% |
| 20% | 65.1% | 7.0% |
| 30% | 52.1% | 11.4% |
| 40% | 41.1% | 16.7% |
| 50% | 31.8% | 23.1% |
| 60% | 23.7% | 31.1% |
| 70% | 16.6% | 41.2% |
| 80% | 10.4% | 54.6% |
| 90% | 4.9% | 73.0% |

FDR: False discovery rate, FOR: False omission rate

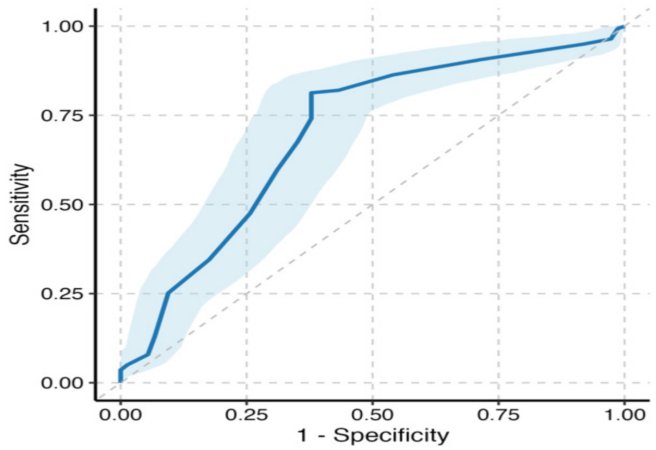


**Figure 4.** False discovery rate and false omission rate curves of posterior fat pad sign across varying disease prevalence for predicting elbow fractures confirmed by computed tomography

## DISCUSSION

This study demonstrates that the PFPS has substantial diagnostic value in detecting elbow fractures in children, especially when confirmed by CT. The presence of PFPS on initial radiographs was significantly associated with CT-confirmed fractures, and its diagnostic accuracy improved further when the posterior fat pad angle was taken into account.

Pediatric elbow fractures represent a significant portion of orthopedic trauma cases in children and are associated with both immediate and long-term functional consequences. Supracondylar and lateral condyle fractures, in particular, can lead to growth disturbances, neurovascular injury, and joint stiffness if not promptly diagnosed and appropriately managed.[11] As such, early recognition is essential not only to prevent complications but also to optimize surgical outcomes and rehabilitation potential. Recent data also suggest that simulation-based training in the management of pediatric elbow fractures improves procedural accuracy and reduces complication rates among orthopedic trainees.[12] Furthermore, postoperative pain control and opioid-sparing strategies, such as brachial plexus block, have been explored to improve perioperative safety in this population.[13]

Conventional radiography is the primary imaging modality used in the evaluation of pediatric elbow injuries due to its rapid availability and low radiation exposure. However, plain X-rays may miss subtle or occult fractures, particularly when bone displacement is minimal or absent. In such cases, CT provides superior sensitivity and can confirm intra-articular involvement, although concerns about radiation dose limit its routine use in children.[14] The PFPS, visible on lateral radiographs, serves as an important indirect indicator of intra-articular effusion and potential fracture. Several studies have emphasized that the presence of PFPS—especially in the absence of visible cortical disruption—should prompt further evaluation or follow-up imaging.[15] The introduction of quantitative approaches, such as measuring the angle between the posterior fat pad and the humeral shaft, may reduce subjective variability and improve diagnostic precision.[16]

Our findings confirm the diagnostic value of the PFPS in pediatric elbow trauma, especially when assessed with angular measurement. The observed association between PFPS angle and fracture presence is consistent with prior literature emphasizing the limitations of plain radiographs in detecting subtle injuries. Afacan et al.[17] reported improved diagnostic performance when PFPS was considered alongside conventional imaging, supporting its role in guiding further evaluation or treatment decisions. The structured use of PFPS angle in our study also aligns with recommendations by Poppelaars et al.,[18] who proposed objective definitions to improve interobserver consistency. Their findings indicate that visible posterior fat pads should not be dismissed, even when no overt fracture is identified on X-ray. Similarly, Burnier et al.[19] observed that PFPS often coincides with occult fractures, reinforcing the clinical relevance of this radiographic marker in early diagnosis.

### Limitations

This study has several limitations. As a retrospective, single-center analysis, its findings may not be generalizable to other clinical settings or populations. The sample consisted exclusively of patients who underwent CT imaging, which may have introduced a selection bias toward more severe or ambiguous cases. Additionally, interpretation of the PFPS may be subject to interobserver variability, although efforts were made to standardize angle measurement. The absence of follow-up data also precludes assessment of long-term clinical outcomes.

## CONCLUSION

The PFPS remains a valuable radiographic finding in the evaluation of pediatric elbow trauma. Its presence was strongly associated with CT-confirmed fractures, and the addition of quantitative angle measurement significantly enhanced diagnostic accuracy. These findings support the integration of both visual and angle-based assessment of

PFPS into emergency radiographic evaluation protocols for children with suspected elbow fractures.

## ETHICAL DECLARATIONS

### Ethics Committee Approval

Approval was obtained from the Ethics Committee of İstanbul Yeni Yüzyıl University (Date: 07.05.2025, Decision No: 2025/05-1541).

### Informed Consent

Because the study was designed retrospectively, no written informed consent form was obtained from patients.

### Referee Evaluation Process

Externally peer-reviewed.

### Conflict of Interest Statement

The authors have no conflicts of interest to declare.

### Financial Disclosure

The authors declared that this study has received no financial support.

### Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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