SCIENTIFIC ARTICLES
OBSERVATIONAL STUDIES

Incidence, Characteristics, and Management of Concomitant Ipsilateral Upper-Extremity Fractures in Pediatric Monteggia Fracture-Dislocations

A 13-Year Single-Institution Case Series

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Background: Monteggia fracture-dislocations are uncommon pediatric injuries that often require surgical stabilization. Concomitant ipsilateral upper-extremity fractures are rare, are poorly characterized, and may be missed during initial evaluation. In this study, we aimed to evaluate the incidence, characteristics, and management of acute pediatric Monteggia fracture-dislocations with concomitant ipsilateral upper-extremity fractures.

Methods: A retrospective review was conducted at a single tertiary academic center from 2011 to 2024. Patients ≤18 years of age with acute Monteggia or Monteggia-equivalent fracture-dislocations were identified and categorized using the Bado classification. Patients with concomitant ipsilateral upper-extremity fractures were identified and reported descriptively. The rates of formal operative reduction and ulnar fracture fixation were compared between patients with and without concomitant fractures.

Results: In total, 468 pediatric patients with Monteggia fracture-dislocations (mean age, 6.3 ± 2.5 years; 49% female; 48% White, 39% Hispanic, 8% Asian, 3% Black, and 2% not specified) were included. Of these, 32 (7%) had ≥1 concomitant ipsilateral upper-extremity fracture. Bado I was most common among patients with concomitant fractures (59%). Concomitant fracture types included distal radial fractures in 59%, supracondylar humeral fractures in 34%, distal ulnar fractures in 25%, medial epicondylar fractures of the humerus in 9%, and lateral condylar fractures of the humerus in 6%. The observed fracture combinations, in decreasing order, were Monteggia fracture-dislocation with distal radial fracture (34%), with supracondylar humeral fracture (25%), and with combined distal radial and distal ulnar fractures (16%). Additional patterns included Monteggia fracture-dislocation with combined supracondylar humeral, distal radial, and distal ulnar fractures (9%); with medial epicondylar fracture of the humerus (9%); and with lateral condylar fracture of the humerus (6%). Patients with concomitant fractures more frequently underwent formal operative reduction (78% versus 48%; $p = 0.001$) and ulnar fracture fixation (66% versus 37%; $p = 0.001$) compared with those with isolated Monteggia fracture-dislocations.

Conclusions: Concomitant ipsilateral upper-extremity fractures were identified in 7% of acute pediatric Monteggia fracture-dislocations, most frequently involving the distal radius (59%) and the supracondylar region of the humerus (34%). Patients with concomitant fractures more commonly underwent formal operative reduction and ulnar fracture fixation compared with those without concomitant fractures. Given the 7% incidence, surgeons should maintain a high index of suspicion for subtle secondary injuries and ensure appropriate imaging during initial evaluation. Further research is needed to guide management and rehabilitation in these complex cases.

Level of Evidence: Therapeutic Level IV. See Instructions for Authors for a complete description of levels of evidence.

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Pediatric Monteggia fracture-dislocations are rare injuries, characterized by radial-head dislocation with an associated ulnar fracture[1,2]. They comprise only 1% of pediatric forearm fractures[3]. These injuries are challenging to manage because of potential instability, malunion, and limitations in forearm rotation[4,5]. While isolated Monteggia fracture-dislocations are well-studied, the impact of concomitant ipsilateral upper-extremity fractures on the management of Monteggia fracture-dislocations remains poorly understood.

Monteggia fracture-dislocations are inherently unstable and often require internal fixation of the ulna to restore radiocapitellar alignment[4]. Additional ipsilateral fractures of the distal humerus, radius, or ulna may further destabilize the injury and complicate management. Although some case reports describe pediatric Monteggia fracture-dislocations with ipsilateral concomitant fractures[6-12], clinical studies on their incidence, injury patterns, and management remain limited.

Accordingly, in the current study, we aimed to characterize and describe the management of acute pediatric Monteggia fracture-dislocations with concomitant ipsilateral upper-extremity fractures. A secondary objective was to compare the frequencies of formal operative reduction and ulnar fracture fixation between patients with and without concomitant fractures.

Materials and Methods

Study Design, Setting, and Participants

This retrospective observational study was conducted at a single tertiary academic center from 2011 to 2024, with institutional review board approval and a waiver of informed consent. The study followed the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines.

Patients ≤18 years of age treated for acute Monteggia or Monteggia-equivalent fracture-dislocations were identified through diagnostic codes and imaging queries of institutional databases. Monteggia fracture-dislocations were classified using the Bado system[1]. Monteggia-equivalent fracture-dislocations were defined as radiocapitellar dislocations with either plastic deformation of the ulna or olecranon fracture[1,5]. Displaced radial neck fractures were considered Monteggia-equivalent if accompanied by a displaced ulnar fracture or plastic deformation.

All cases were reviewed by the first author to confirm eligibility and to screen for potential concomitant ipsilateral upper-extremity fractures. Cases were flagged if any of the following were present: radiographic evidence of a concomitant fracture, provider documentation noting suspicion or confirmation of a concomitant fracture, or radiology reports describing possible additional fracture, including potentially unrelated or healing injuries.

Concomitant ipsilateral upper-extremity fractures were defined as involving the ipsilateral humerus, radius, or ulna. Radial or ulnar fractures were considered concomitant if they occurred distal to the junction of the middle and distal thirds of the bone. Fractures distal to the carpal bones or proximal to the humerus were not considered.

All flagged cases were reviewed by 2 fellowship-trained pediatric orthopaedic surgeons to confirm and classify Monteggia injuries and concomitant fractures. Formal interrater reliability was not assessed because of the small sample size. Fracture type and location were recorded, and discrepancies were to be resolved by the senior author, although none occurred.

Exclusion criteria included chronic fractures (>30 days post-injury), treatment at unaffiliated hospitals, cases with no available imaging or miscoded cases, and fractures that did not meet Monteggia fracture-dislocation criteria (e.g., isolated radial neck fractures without ulnar involvement) (Fig. 1).

Data Collection

Electronic medical records were reviewed for demographics, injury mechanisms, fracture characteristics, and treatment. Operative reports for patients with concomitant fractures were reviewed for intraoperative details.

Mechanisms of Injury

Mechanisms of injury were abstracted from documentation and categorized as follows: ground-level falls, playground-related falls, falls from a height, sports-related injuries, vehicle-related trauma, animal-related trauma, and direct trauma. Falls from a height included any fall above ground level. Animal-related trauma included falls from, or injuries caused by, animals. When multiple categories applied, the primary contributing factor was used. For example, trampoline injuries were classified as sports-related unless the fall occurred during dismounting, which was considered a fall from a height. Mechanisms are reported descriptively. For comparative analysis, mechanisms were dichotomized as ground-level versus non-ground-level falls to improve parsimony and reduce misclassification.

Assessment of Management

Initial closed reduction in the emergency department, with or without conscious sedation, was attempted in most cases unless deferred because of anticipated operative fixation or

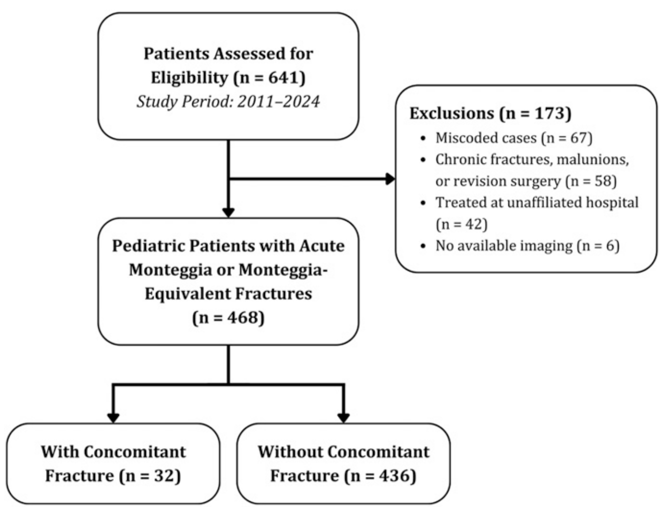

Fig. 1

Flowchart showing study inclusion and exclusion criteria.

neurovascular concerns, consistent with institutional practice. Formal operative reduction was defined as any reduction performed in the operating room, including closed reduction under general anesthesia, closed reduction with percutaneous pinning, or open reduction with internal fixation.

All acute Monteggia fracture-dislocations were included in a secondary analysis comparing patients with and without concomitant fractures to evaluate differences in the rates of formal operative reduction and ulnar fixation specific to the Monteggia component.

> *Concomitant ipsilateral upper-extremity fractures were identified in 7% of acute pediatric Monteggia fracture-dislocations, most frequently involving the distal radius (59%) and the supracondylar region of the humerus (34%).*

Statistical Analysis

Patient characteristics and concomitant fractures are summarized descriptively. Percentages for fracture types are inclusive and may sum to >100% because some patients sustained >1 concomitant fracture. Age was compared using the Mann-Whitney U test after assessing normality with the Shapiro-Wilk test. Chi-square tests were used to compare patient sex, mechanism of injury, and management. A post-hoc power analysis assessed the ability to detect differences based on the observed effect size, sample size, and $\alpha = 0.05$. Analyses were performed using SPSS Statistics (version 29; IBM), with significance set at $p \leq 0.05$.

Results

Study Population

Of 468 pediatric patients with Monteggia fracture-dislocations, 32 (7%) had ≥1 concomitant ipsilateral upper-extremity fracture. The cohort included 231 females (49%) and had a mean age (and standard deviation) of 6.3 ± 2.5 years (range, 0.8 to 17.2 years). Race and ethnicity distributions were 48% White, 39% Hispanic, 8% Asian, 3% Black, and 2% not specified. Age ($p = 0.63$) and sex ($p = 0.06$) did not differ significantly between patients with and without concomitant fractures. Demographics and injury mechanisms are summarized in Table 1.

Notably, none of the patients with concomitant fractures sustained a ground-level fall, while 20% of those with isolated Monteggia injuries sustained a ground-level fall ($p = 0.006$). Post-hoc power for this comparison was 0.79.

Concomitant Fracture Characteristics and Treatment Strategies

Among patients with concomitant fractures (n = 32), the most common Monteggia fracture-dislocation type was Bado I (59%), followed by Bado III (22%), Bado IV (16%), and Bado II

Table 1. Demographics and Injury Mechanism

Variable	Isolated Monteggia Fracture (N = 436)	Monteggia with Concomitant Fracture (N = 32)	P Value
Age* *(yr)*	6.3 ± 2.6 (0.8-17.2)	6.3 ± 2.1 (2.4-11.9)	0.63†
Female sex *(no. [%])*	210 (48%)	21 (66%)	0.06‡
Race and ethnicity§ *(no. [%])*			
White	209 (48%)	16 (50%)	—
Hispanic	170 (39%)	12 (38%)	—
Black	13 (3%)	1 (3%)	—
Asian	36 (8%)	3 (9%)	—
Not specified	8 (2%)	0 (0%)	—
Mechanism of injury *(no. [%])*			
Ground-level fall	85 (20%)	0 (0%)	—
Playground-related fall	127 (29%)	17 (53%)	—
Fall from height	98 (22%)	8 (25%)	—
Sport-related injury	66 (15%)	1 (3%)	—
Vehicle-related trauma	42 (10%)	4 (13%)	—
Animal-related trauma	7 (2%)	2 (6%)	—
Direct trauma	11 (3%)	0 (0%)	—

*The values are given as the mean and standard deviation (range). †Mann-Whitney U test used due to non-normal distribution (Shapiro-Wilk; $p < 0.001$) ‡Pearson chi-square test (2-sided). §Race and ethnicity were self-reported and abstracted from the medical record.

Fig. 2-A

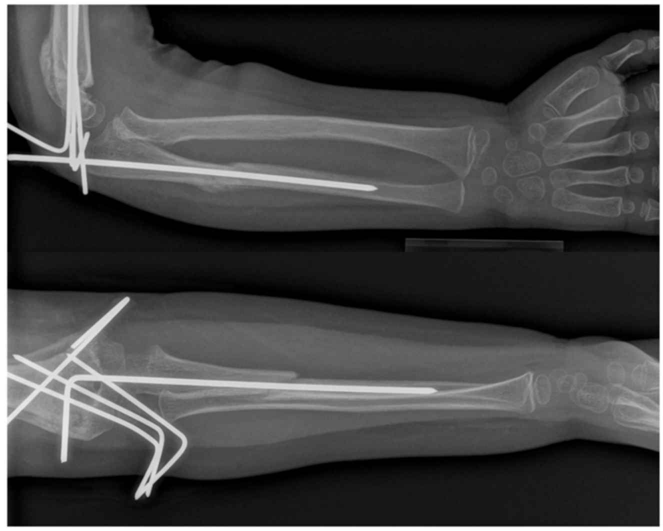

Fig. 2-B

Figs. 2-A and 2-B: Composite radiographs from the case of a 4-year-old girl who sustained a closed Bado type-I Monteggia fracture-dislocation with a concomitant Gartland type-III supracondylar humeral fracture (**Fig. 2-A**). The Monteggia component was reduced using longitudinal traction and dorsal pressure and stabilized with a 2.0-mm intramedullary Steinmann pin. The supracondylar fracture was fixed with 3 lateral and 1 medial Kirschner wires. Postoperative radiographs (**Fig. 2-B**) show maintained alignment, bridging callus at the distal humerus, and early healing of the ulna, with mild residual dorsal angulation. The patient returned to full activity by 8 weeks. (See Appendix Fig. A2 for complete imaging.)

(3%). Five (16%) of the patients had open fractures involving the Monteggia component. One (3%) of the patients with a Gartland type-III supracondylar humeral fracture also had an open injury.

Concomitant fracture types included distal radial fractures in 59% (n = 19), supracondylar humeral fractures in 34% (n = 11), distal ulnar fractures in 25% (n = 8), medial epicondylar fractures of the humerus in 9% (n = 3), and lateral condylar fractures of the humerus in 6% (n = 2).

Observed fracture patterns included Monteggia fracture-dislocation with distal radial fracture (34%; n = 11), Monteggia fracture-dislocation with supracondylar humeral fracture (25%; n = 8) (Figs. 2-A and 2-B), and Monteggia fracture-dislocation with combined distal radial and distal ulnar fractures (16%; n = 5). Additional patterns included Monteggia fracture-dislocation with combined supracondylar humeral, distal radial, and distal ulnar fractures (9%; n = 3) (Figs. 3-A and 3-B); Monteggia fracture-dislocation with medial epicondylar fracture of the humerus (9%; n = 3) (see Appendix Fig. A1); and Monteggia fracture-dislocation with lateral condylar fracture of the humerus (6%, n = 2).

Twenty-five (78%) of the patients underwent formal operative reduction. The Monteggia component was treated with open reduction and internal fixation of the ulna in 19 (59%), closed reduction with percutaneous pinning of the ulna in 2 (6%), and closed reduction under general anesthesia in 4 (13%). Concomitant fractures were treated with additional fixation in 14 patients (44%), with strategies varying by fracture pattern (Table 2).

All patients were immobilized in a long-arm cast for a mean of 31 ± 8.7 days (range, 18 to 52 days). In 14 cases, pins used to fix either the Monteggia component or concomitant fracture were left exposed and were removed at a mean of 31 ± 8.3 days (range, 18 to 50 days).

Comparison of Management Strategies

Patients with concomitant fractures were significantly more likely to undergo formal operative reduction (78% [25 of 32]) compared with those with isolated Monteggia fracture-dislocations (48% [210 of 436]) (p = 0.001). They were also more likely to undergo ulnar fracture fixation (66% [21 of 32] versus 37% [160 of 436]; p = 0.001).

Post-hoc analysis confirmed adequate statistical power: 0.90 for formal operative reduction (effect size, 0.15) and 0.90 for ulnar fracture fixation (effect size, 0.15).

Discussion

Concomitant ipsilateral upper-extremity fractures were identified in 7% of acute pediatric Monteggia fracture-dislocations and represent rare but clinically challenging injuries. The most frequent sites were the distal radius (59%) and supracondylar region of the humerus (34%). Patients with concomitant fractures more often underwent formal operative reduction and ulnar fracture fixation than those with isolated Monteggia injuries. Given the 7% incidence, surgeons should maintain a high index of suspicion for subtle secondary fractures and obtain appropriate imaging during initial evaluation. Recognizing these patterns may aid surgical planning and also inform future research.

A key finding was that 78% of patients with concomitant fractures (25 of 32) underwent formal operative reduction. Of these, 88% (22 of 25) underwent fixation, including both the ulna and concomitant fracture (n = 13), ulna only (n = 8), or concomitant fracture only (n = 1). A "Monteggia-first" strategy

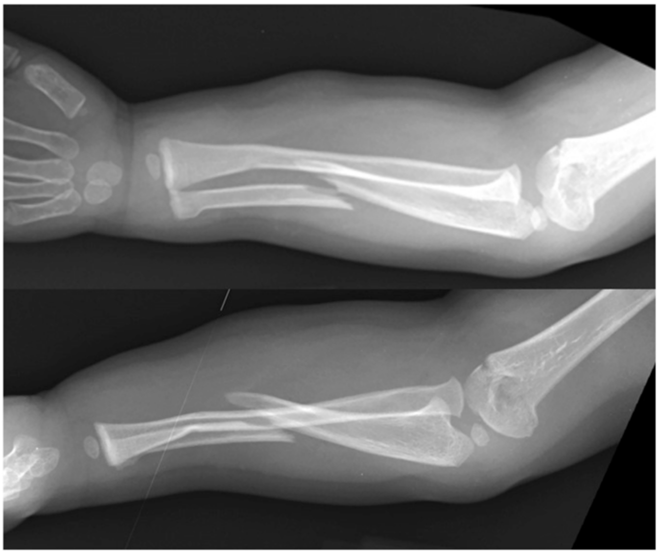

Fig. 3-A

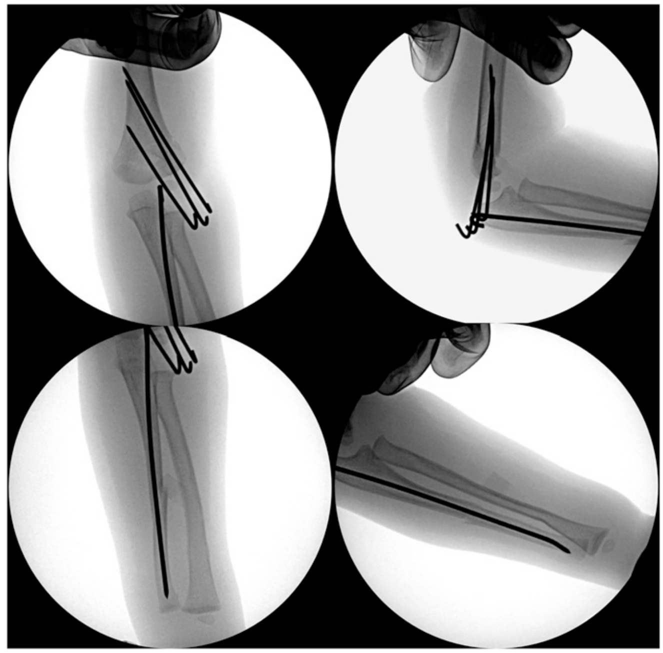

Fig. 3-B

Figs. 3-A and 3-B: Composite images from the case of a 28-month-old girl with a closed Bado type-I Monteggia fracture-dislocation, with concomitant combined Gartland type-IIB supracondylar humeral fracture, distal radial greenstick fracture with apex-volar angulation, and distal ulnar buckle fracture (**Fig. 3-A**). Intraoperative fluoroscopy (**Fig. 3-B**) shows supracondylar fixation with 3 lateral-entry Kirschner wires, and intramedullary fixation of the ulna with a 2.0-mm Steinmann pin. The distal radial and ulnar fractures were managed without manipulation. The patient achieved full range of motion without complication. (See Appendix Fig. A3 for complete imaging.)

was used in 76% (19 of 25), first stabilizing the ulna and confirming radial-head reduction before addressing the concomitant fracture. This approach was particularly effective when the concomitant injury was relatively stable or minimally displaced (e.g., buckle-type distal radial fracture, Gartland type-IIA supracondylar humeral fracture), typically requiring only casting without manipulation or percutaneous pinning. When performed, ulnar fixation most commonly involved intramedullary devices, which were favored in younger patients or simpler fracture patterns[13,14]. Plate fixation was used selectively (n = 3) for older patients (≥8 years) with comminuted proximal ulnar fractures.

In 24% (6 of 25) of the operative cases, surgeons deviated from a “Monteggia-first” approach. Reasons included “floating elbow” scenarios with an unstable supracondylar humeral fracture, distal radial fractures that were simpler to pin first, or open or comminuted concomitant injuries needing prompt debridement and stabilization[3,5,15]. In these instances, addressing the distal or elbow fracture first may have helped to minimize repeated manipulations, restore limb stability, and facilitate more controlled correction of the ulna and radial head[1,3,5]. Further study is needed to define optimal treatment strategies in these complex injuries.

In this study, confirming anatomic radial-head reduction often required more than standard anteroposterior, lateral, and oblique fluoroscopic views[16,17]. In 20% (5 of 25) of the operative cases, intraoperative contrast arthrography was used to identify subtle radiocapitellar incongruity or soft-tissue interposition, particularly in cases of proximal ulnar comminution or Monteggia-equivalent lesions[18,19]. Arthrography may help to reveal minor displacements that, if unrecognized, can predispose patients to chronic instability and poor outcomes[20,21]. Larger studies are needed to better define its role in Monteggia fracture-dislocations with concomitant fractures.

The management of concomitant fractures varied on the basis of displacement and soft-tissue status. Minimally displaced distal forearm or humeral fractures were managed with casting, with or without brief manipulation, after ulnar alignment. Markedly displaced distal radial fractures underwent single-pin fixation. All Gartland type-IIB or III supracondylar humeral fractures were treated with 2 or 3 pins, most commonly with lateral-entry pins alone (71% [5 of 7]) and less commonly with combined medial and lateral pin constructs (29% [2 of 7]).

Monteggia fracture-dislocations typically result from moderate- to high-energy trauma[22], and the presence of concomitant fractures may indicate greater force. In this study, ground-level falls occurred in 20% of isolated Monteggia injuries but were absent in those with concomitant fractures, supporting a higher-energy threshold. While further study is warranted, these findings suggest that higher-energy mechanisms contribute to multilevel fracture patterns in pediatric Monteggia fracture-dislocations.

Furthermore, biomechanical forces may explain the observed patterns. Concomitant distal radial fractures were most common, typically presenting as dorsally

Table 2. Injury Patterns and Treatment of Monteggia Fracture-Dislocations with Concomitant Fractures (N = 32 Patients)*

Injury Pattern	No. (%)	No. (%) with Open Fracture	Bado Type (No.)	Treatment of Monteggia Component	Treatment of Concomitant Fracture(s) (No.)
Monteggia + distal radial fracture	11 (34%)	2 (18%)	I (8); III (1); IV (2)	ORIF (n = 6); CR (n = 5)	CR (n = 9); ORIF (n = 1); CRPP (n = 1)
Monteggia + supracondylar humeral fracture	8 (25%)	4 (50%)	I (7); IV (1)	ORIF (n = 6); CR (n = 2)	CRPP (n = 5); CR (n = 3)
Monteggia + combined distal radial and distal ulnar fractures	5 (16%)	0 (0%)	I (1); III (4)	ORIF (n = 3); CR (n = 2)	CR (n = 4); CRPP (n = 1)
Monteggia + combined distal radial, distal ulnar, and supracondylar humeral fractures	3 (9%)	0 (0%)	I (2); III (1)	ORIF (n = 3)	CRPP (n = 2); CRPP + ORIF of distal radial fracture (n = 1)
Monteggia + medial epicondylar fracture	3 (9%)	0 (0%)	I (1); IV (2)	CRPP (n = 2); ORIF (n = 1)	ORIF (n = 1); ORIF + ulnar nerve decompression (n = 1); CR (n = 1)
Monteggia + lateral condylar fracture	2 (6%)	0 (0%)	II (1); III (1)	CR (n = 2)	CRPP (n = 1); CR (n = 1)

*ORIF = open reduction and internal fixation, CR = closed reduction with or without manipulation, and CRPP = closed reduction and percutaneous pinning.

angulated buckle fractures consistent with axial loading through a supinated, extended wrist[3,23]. Residual force may propagate proximally through the forearm unit, predisposing the ulna to failure and the radial head to anterior dislocation[6,24-27].

In some cases, continued loading may shift forces medially, increasing shear stress across the distal ulna[8,28]. This may explain combined distal radial and distal ulnar fractures, where the ulnar injury often presented as metaphyseal impaction rather than complete cortical disruption[23,29]. Monteggia injuries with combined distal radial and distal ulnar fractures were mainly Bado III (4 of 5), possibly reflecting this altered load distribution and varus moments at the elbow[2,28].

Concomitant supracondylar humeral fractures were the second-most common, and likely resulted from elbow hyperextension with axial loading through the forearm, producing an extension-type fracture[30,31]. Continued force may lead to proximal ulnar failure and anterior radial-head dislocation[1,2], consistent with the Bado-I and IV patterns in our cohort. The absence of Bado-II and III patterns suggests that rotational forces were less contributory.

Medial epicondylar fractures, observed in Bado-I and IV injuries, likely reflect valgus overload from flexor-pronator tension or trochlear impingement during hyperextension[32-34]. In Bado-IV injuries, radial and ulnar fractures may further destabilize the elbow and increase stress across the medial epicondylar physis, predisposing it to failure[34,35]. Lateral condylar fractures likely result from axial loading with varus stress, either via tensile shear across the lateral physis or radial-head impaction against the condyle[36-38].

Three patients sustained multilevel concomitant injuries involving Monteggia fracture-dislocations with combined distal radial, distal ulnar, and supracondylar humeral fractures. These cases may reflect complex trauma rather than a reproducible biomechanical pattern. Although none of these patients had diagnosed bone disorders or suspected nonaccidental trauma, clinicians should consider these possibilities in similar cases, especially when high-energy mechanisms are absent[39,40]. Notably, another patient in the cohort—with a concomitant supracondylar humeral fracture—had known osteogenesis imperfecta, supporting this consideration.

This study had several limitations. The retrospective design and small sample size may have introduced selection bias, reduced generalizability, and precluded causal inferences. External validity is limited by the rarity of Monteggia fracture-dislocations with concomitant fractures and the single-institution design, despite the pediatric center being high volume. Surgeon-dependent variation in management may limit the reproducibility across institutions. Complete imaging of the ipsilateral upper extremity was unavailable for some patients, particularly transfers from outside hospitals, potentially underestimating concomitant fractures. Two concomitant fractures (buckle-type distal radial and Gartland type-IA supracondylar humeral) were not documented by the attending physician but were noted by the radiologist or evaluating resident. These likely reflect documentation oversights rather than true misses but highlight the risk of underrecognizing subtle injuries.

Suboptimal imaging in young patients (mean age, 6.3 years), often due to apprehension or limited communication, may have limited fracture detection. Behavioral and environmental factors, such as supervision at the time of injury or characteristics of the impact surface, were inconsistently documented and could not be analyzed, although they may influence injury severity. Prospective multicenter studies with standardized imaging, detailed documentation of injury mechanism, and consistent criteria for addressing the concomitant fracture before the Monteggia component are warranted to validate these findings.

Conclusions

Concomitant ipsilateral upper-extremity fractures were identified in 7% of acute pediatric Monteggia fracture-dislocations, with the most frequent involving the distal radius (59%) and the supracondylar region of the humerus (34%). Patients with concomitant fractures more commonly underwent formal operative reduction and ulnar fixation compared with those with isolated Monteggia injuries. Given the 7% incidence, surgeons should maintain a high index of suspicion for subtle secondary injuries and ensure appropriate imaging during initial evaluation. Future research should investigate management strategies, long-term outcomes, and rehabilitation protocols for these complex injuries.

Appendix

eA Supporting material provided by the authors is posted with the online version of this article as a data supplement at jbjs.org (http://links.lww.com/JBJS/I931). ■

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