7 Posterior Monteggia Fracture-Dislocations

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Background

Historical Perspective

Classically, *Monteggia fractures* have been described as diaphyseal ulnar fractures associated with radial head dislocation. In 1814, Monteggia described two clinical cases of a proximal-third diaphyseal ulna fracture associated with anterior dislocation of the radial head and highlighted the residual radial head instability after closed management of the injuries. Further classification and description of Monteggia fractures was refined by Bado, in 1967, who recognized that radial head instability may occur anteriorly, posteriorly, or laterally and that the associated ulna fracture may occur at the diaphysis or more proximally and with or without an associated radial shaft fracture [1]. Whereas the anterior variant of Monteggia injuries is more common among the pediatric population, the posterior Monteggia is more common among adults [2–4]. Historically, outcomes of Monteggia fractures were inconsistent and often poor [5–9]. Although treatment of these injuries remains a challenge, advances in imaging techniques, a greater understanding of the anatomy and stabilizers of the elbow and enhanced methods of internal fixation have led to improved outcomes [10–14].

Elbow Anatomy and Stability

The elbow is a complex joint with three articulations (ulnohumeral, radiocapitellar, and proximal radioulnar) that permit stable range of motion of the forearm through flexion-extension and pronation-supination (Fig. 7.1). Stability of the elbow is dependent upon the highly congruous articular surfaces as well as medial and lateral ligamentous structures [15–17]. The trochlear notch formed between the coronoid and olecranon processes provides a nearly 180° arc of articulation with the distal humerus but has a transverse bare-spot devoid of articular cartilage at its lowest point. In profile, the coronoid projects higher than the olecranon, such that a line drawn from the tips of the coronoid and olecranon

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processes, should form a 30° angle with a line drawn along the axis of the ulna. The sublime tubercle on the medial aspect of the coronoid serves as the insertion site of the medial collateral ligament, which provides primary stability against valgus-forces throughout the range of elbow motion [15–18]. The radial head, which articulates with the capitellum and the proximal ulna, is a secondary stabilizer to valgus forces. The lateral ulnar collateral ligament complex is composed of the radial collateral ligament, lateral ulnar collateral ligament, and the annular ligament (Fig. 7.2). The annular ligament encircles the radial head with an origin and insertion on the proximal ulna and provides stability to the proximal radio-ulnar joint. The radial collateral ligament provides restraint against varus forces and originates on the lateral epicondyle and has a broad insertion along the annular ligament [15, 19]. The lateral ulnar collateral ligament takes origin off of the lateral epicondyle and traverses the posterior half of the radial head before inserting on the crista supinatoris of the proximal ulna providing restraint against posterolateral rotatory instability.

Fig. 7.1 Bony anatomy of elbow joint. Anterior view of distal humerus and proximal radius and ulna demonstrate highly congruous joint surfaces (From Wong JC, Getz CL, Abboud JA. Adult Monteggia and Olecranon Fracture Dislocations of the Elbow. *Hand Clin*. 2015;31(4):565–80)

The relative contributions of the bony and ligamentous structures to elbow stability have been studied biomechanically [20–25]. Whereas elbow stability may be maintained with isolated fractures of the coronoid up to 50 % of the coronoid height, smaller coronoid fractures in conjunction with ligamentous or radial head injury can lead to joint instability [23–27]. These studies help to underscore the complementary nature of the bony and ligamentous stabilizers of the elbow. When treating complex elbow dislocations such as the

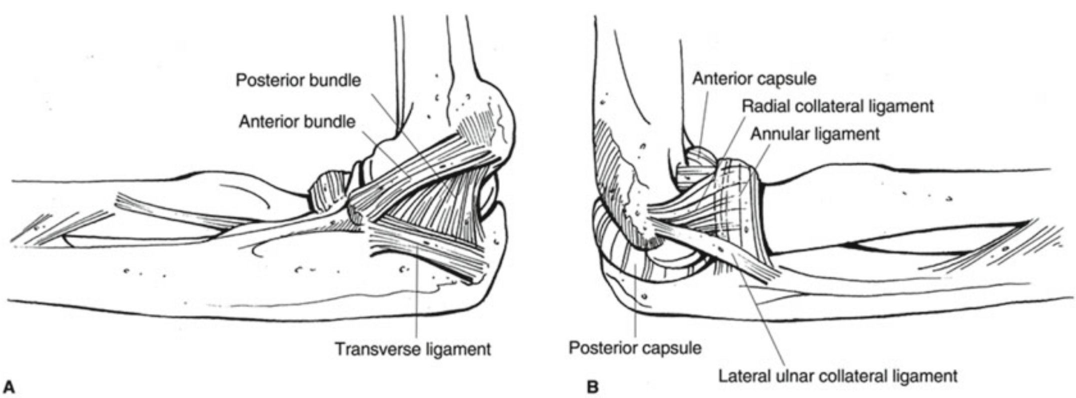

Fig. 7.2 Elbow ligamentous anatomy. Structure of the medial collateral ligament complex (**a**) and the lateral collateral ligament complex (**b**) (From Tashjian RZ, Katarinic JA. Complex elbow instability. *J Am Acad Orthop Surg*. 2006;14(5):278–86)

posterior Monteggia fracture-dislocation, it is critical to identify and manage all of the bony or ligamentous stabilizers of the elbow so that joint stability may be restored and early range of motion may be performed to optimize outcomes.

Classification of Injury Pattern

Bado described a four-category classification of Monteggia fractures based upon the direction of radial head displacement and whether or not an associated fracture of the radial diaphysis was present (Fig. 7.3).

- In Type I fractures, there is apex anterior angulation of the ulnar fracture and anterior dislocation of the radial head.
- Type II fractures demonstrate apex posterior ulnar fracture with posterior or posterolateral dislocation of the radial head.
- Type III fractures demonstrate metphyseal ulnar fractures with lateral radial head dislocation.
- Type IV fractures concomitant radial and ulnar diaphyseal fracture in conjunction with anterior radial head dislocation.

A more simplified approach has been proposed to classify adult Monteggia fractures as occurring either anteriolateral (Bado Type I, III, and IV) or posterior (Bado Type II) [28]. The anterolateral Monteggia injuries in adults occur predominantly through the ulnar diaphysis with anterolateral radial head dislocation, but importantly do not have any element of ulnohumeral

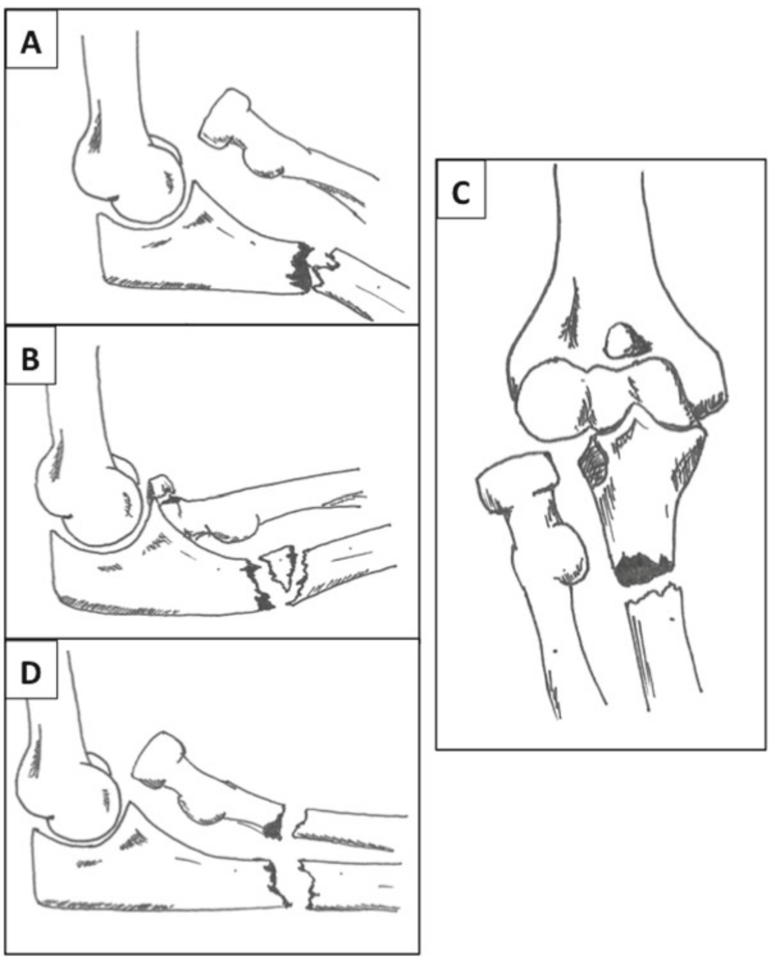

Fig. 7.3 Bado classification of monteggia fractures. (**a**) Type I—Anterior Monteggia, (**b**) Type II—Posterior Monteggia, (**c**) Type III—Lateral Monteggia, (**d**) Type IV—Monteggia fracture with diaphyseal radial shaft fracture (From Wong JC, Getz CL, Abboud JA. Adult Monteggia and Olecranon Fracture Dislocations of the Elbow. *Hand Clin*. 2015;31(4):565–80)

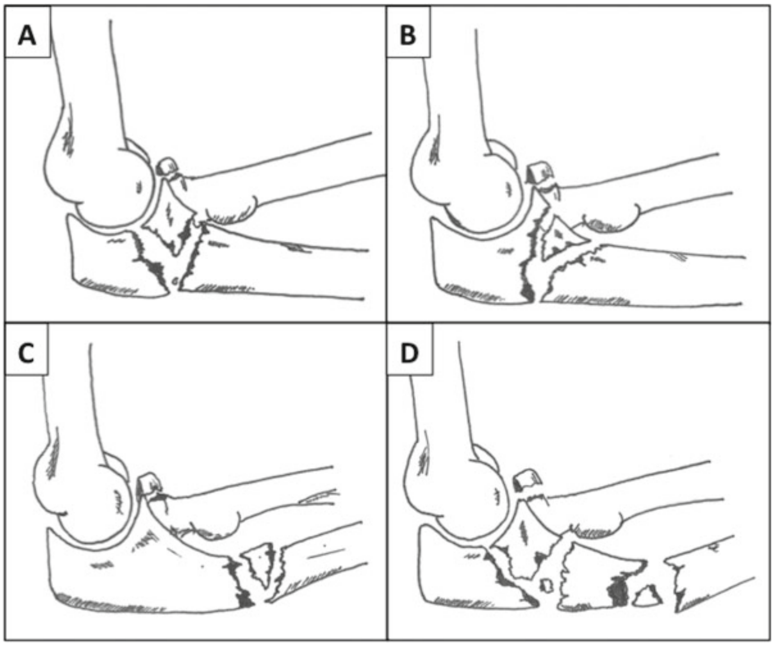

Fig. 7.4 Jupiter sub-classification of posterior monteggia fractures. (**a**) IIA—the ulnar fracture involves the distal olecranon and coronoid process, (**b**) IIB—the ulnar fracture is at the metaphyseal-diaphyseal junction distal to the coronoid, (**c**) IIC—the ulnar fracture is diaphyseal, (**d**) IID—ulnar fracture extends along proximal third to half of the ulna (From Wong JC, Getz CL, Abboud JA. Adult Monteggia and Olecranon Fracture Dislocations of the Elbow. *Hand Clin*. 2015;31(4):565–80)

instability. Treatment of anterolateral Monteggia injuries is directed at restoration of ulnar length and alignment to indirectly achieve radial head reduction. It is rarely necessary that the proximal radiocapitellar joint be opened to achieve radial head reduction, but may be necessary in some cases as a result of annular ligament interposition [11, 28]. In contrast, the posterior Monteggia injury has been shown to have more concomitant injuries involving either the radial head, coronoid process, or lateral ulnar collateral ligament complex, which sometimes results in ulnohumeral instability [10, 12, 29]. Posterior Monteggia fractures (Bado Type II) are further subclassified based upon the location of the ulnar fracture in relation to the coronoid process, with the IIA and IIB subtypes being the most common [10, 12] (Fig. 7.4). In particular, when the fracture involves the coronoid process (IIA, IID), the fragment is often a large anterior quadrangular or triangular fragment that requires anatomic reduction to restore ulnohumeral joint stability.

- Type IIA—fracture of proximal ulna involving the coronoid process
- Type IIB—fracture occurring distal to the coronoid process at the junction of the ulnar metaphysis and diaphysis
- Type IIC—fracture along the ulnar diaphysis
- Type IID—severely comminuted fracture of ulna extending from olecranon to ulnar diaphysis

Evaluation

The posterior Monteggia fracture occurs most commonly in elderly females with underlying osteoporotic bone as a result of low-energy ground level fall [10, 12]. Although these injuries may occur in isolation, patients have been observed to have concomitant skeletal, thoracoabdominal, or head trauma in up to 30% of cases [10, 12]. This is a reminder that initial evaluation of any trauma patient should begin according to the Advanced Trauma Life Support protocol. Once deemed stable, a more thorough evaluation of the extremity can begin. While posterior Monteggia lesions are most often closed injuries, attention should be paid to the soft-tissue envelope to look for potential open injury. Concomitant injury proximally, distally, or in the contralateral extremity is not uncommon and should be thoroughly assessed. Vascular injury is rare in Monteggia fracture dislocations, but injury to the posterior interosseous nerve or ulnar nerve has been reported although nerve exploration is not usually required and spontaneous resolution is often observed [12]. Although rare, compartment syndrome has been reported [11].

Standard anterior-posterior, lateral, and oblique radiographs of the elbow and forearm should be obtained to evaluate the osseous injuries. As previously mentioned, if the ulnar fracture involves the coronoid process the fracture fragment is often large and represents a significant loss to intrinsic ulnohumeral stability, which may result in ulnohumeral subluxation/dislocation. Associated radial head fractures are common and are thought to occur through a shearing mechanism as the radial head dislocates posterolaterally across the capitellum [9, 10, 29]. If standard radiographs are unable to provide a clear picture of the spectrum of injury, then cross-sectional imaging such as computed tomography should be obtained.

Initial management of these injuries should include well-padded splinting of the elbow in a comfortable position. Due to the inherent instability of these injuries, closed reduction is unlikely to be successful and excessive manipulation of the elbow/forearm should be avoided. Ideally, definitive surgical management of these injuries should occur as soon as the patient is medically stable for surgery.

Treatment Algorithm

The goals of treatment include (1) a stable elbow joint including radiocapitellar as well as ulnohumeral joint and (2) stable internal fixation of the ulna fracture to permit early range of motion. The treatment algorithm may be broken down into the individual components of the injury pattern. The radial head dislocation is often reduced indirectly when ulnar length and alignment has been restored. When the ulnar fracture is at the level of the coronoid it is imperative that the coronoid fracture fragment be incorporated into the fixation construct and that an anatomic reconstruction of the trochlear notch be achieved.

Radial head fractures may be seen in 35–100 % of posterior Monteggia injuries and are commonly Mason type II or III [8–11, 30, 31]. Type II radial head fractures should undergo open reduction and internal fixation. Historically, type III radial head fractures were either fixed or excised and outcome measures did not appear to demonstrate significant complication resulting from radial head excision [10–12]. However, since these injuries may also occur in conjunction with lateral ulnar collateral ligament injury it may be prudent for the surgeon to consider metallic radial head replacement as opposed to excision for type III injuries to minimize the chance of persistent instability. Lateral ulnar collateral ligament repair may also be necessary if intraoperative assessment demonstrates residual ulnohumeral instability despite stable anatomic fixation of the coronoid, olecranon, and radial head [29].

Nonoperative Strategies

While Monteggia injuries in children can be treated nonoperatively with closed reduction and casting, there is little role for nonoperative management of Monteggia injuries in adults. Although it may be possible to perform closed reduction of the ulna and radial head in simple ulna fracture patterns, loss of reduction is common and stable internal fixation of the ulna is recommended [10].

Surgical Management and Techniques

These injuries are approached through the posterior approach to the elbow with an extension along the subcutaneous border of the ulna. If the ulnar fracture is proximal, access to the radial head can often be obtained through the fracture bed. Alternatively, for diaphyseal ulnar fractures, access to the radial head can be obtained through a separate lateral incision or through elevation of the posterolateral skin flap. For fractures at the ulnar metaphysis and more proximally, the ideal fixation construct involves a 3.5 mm dynamic compression plate or a limited contact dynamic compression plate placed along the dorsal cortex of the ulna and contoured around the olecranon so that the proximal screws are orthogonal to the more distal screws [11–14, 32]. Constructs with tension band wiring, tubular, or semi-tubular plates provide inadequate fixation and are at risk for loss of fixation [32]. Similarly, for fractures proximal to the metaphysis, medial or lateral placement of the plate may only permit one to two screws to be engaged in the proximal olecranon fragment [11, 32]. True diaphyseal ulna fractures may be fixed with the plate placed volarly or dorsally to minimize hardware prominence and the need for late hardware removal.

Typically, reduction of the radial head is achieved by restoring length and alignment of the ulna fracture. The injury may be fixed step-wise either from proximal-to-distal or distal-to-proximal [14, 29, 33]. Ring and Jupiter have advocated the use of a distractor to allow for indirect reduction of the ulnar fracture fragments in cases with severe comminution along the trochlear notch [29]. The first step involves placement of a smooth 0.062 Kirschner wire through the olecranon fragment and into the distal humerus. Distraction is then achieved between the K-wire and a second wire or pin that is placed in the distal ulna away from the fracture and out of the way of the intended are of definitive fixation. The distal humerus can be utilized as a template to reconstruct the ulnar trochlea.

Alternatively, Beingessner et al. have proposed a stepwise approach from distal-to-proximal for the extensively comminuted Type IID posterior Monteggia injuries, but their principles may be applicable to all posterior Monteggia fractures and ensure that the surgeon has addressed all of the bony and ligamentous contributions to elbow and forearm stability [14]. If the radial head is fractured and accessible through the ulnar fracture plane, then the first step should be reduction and fixation of the radial head or prosthetic replacement if the surgeon feels it cannot be fixed. Radial head fractures with more than three articular fragments may be better served with prosthetic replacement—internal fixation of more comminuted radial head fractures commonly results in radial head malunion and loss of forearm rotation [34]. After the radial head has been addressed, a combination of lag screws and mini-fragment plates can be utilized to reconstruct the ulnar shaft from distal-to-proximal. If the radial head cannot be accessed through the ulna fracture, the ulna should be repaired and then the radial head addressed through a lateral approach (Kocher, Kaplan or EDC split—see Chap. 3). The reduction of the coronoid fragment can be obtained through one of the ulnar fracture planes. Smaller coronoid fragments may require transosseous suture fixation whereas larger coronoid fragments may potentially be captured with screws. The most proximal portion of the ulna fracture (olecranon) is addressed last with provisional reduction of the olecranon to the distal ulna with pointed reduction clamps and placement of a contoured 3.5-mm compression plate along the dorsal cortex of the ulna. After the osseous structures are stabilized, attention should be paid to potential injury of the medial or lateral ulnar collateral ligaments—with lateral ulnar collateral ligament injuries being more common as a result of the posterior dislocation of the radial head.

When the fracture involves the trochlear notch (Types IIA and IID) it is imperative that the relative relationship of the coronoid and olecranon processes be reconstructed. It is important to remember that there is a naturally occurring bare spot devoid of articular cartilage at the low point of the trochlear notch. Overall, restoration of the relative alignment of the coronoid and olecranon processes to one another may be more important than residual articular incongruity from fracture comminution [35]. Shortening of the olecranon should be avoided if there are comminuted areas of the articular surface at the level of the greater sigmoid notch. The dorsal aspect of the olecranon should be used as the key for olecranon length. Excessive shortening will result in anterior and posterior impingement with flexion and extension restricting motion. Fluoroscopy should be utilized throughout the case to ensure that the ulna is being reconstructed anatomically and that screw tips do not penetrate articular surfaces. The elbow should be put through a gentle range of motion to ensure unrestricted motion and joint stability. If radiocapitellar instability persists then attention should be paid to ensure that appropriate length and alignment of the ulna has been restored. A hinged external fixator to complement internal fixation may be used at the discretion of the surgeon [36]. Our preference is to always check radiocapitellar and ulnohumeral alignment using intraoperative fluoroscopy after fixation is achieved but prior to wound closure. The elbow joint is placed through a flexion-extension arc with the forearm in pronated, neutral, and supinated positions. With the elbow in full extension and forearm in full supination, we carefully scrutinize the lateral view looking for any malalignment of the radiocapitellar joint that would suggest lateral ulnar collateral ligament injury.

Postoperative management for these complex elbow injuries is dictated by multiple factors, including (1) stability of fracture fixation achieved intraoperatively, (2) stability of elbow joint, (3) condition of soft-tissue envelope, and (4) presence or absence of concomitant injury. For the majority of patients, restoration of anatomic bone alignment with stable internal fixation results in a stable elbow joint, which will permit early motion of the elbow. Postoperatively, patients are placed in a well-padded anterior splint with the elbow held in 15–30° of flexion. The anterior placement of the splint limits the pressure over the posterior incision. The splint is maintained for 2 days then removed and the skin incision is assessed. If wound healing allows, the patient is transitioned into a soft dressing and gentle active-assisted range of motion is initiated. The elbow is protected in a sling when exercises are not being performed. If necessary, the splint is continued up to 2 weeks to limit elbow motion and permit wound healing. Serial follow-up is obtained at 2 weeks, then monthly until radiographic union. Passive range of motion and use of nighttime static flexion or static extension splints to help with terminal flexion or extension, are initiated at 6 weeks if necessary. Strengthening is initiated at 2 months if bony healing and elbow range of motion permits.

Published Outcomes/Complications

Historically, the outcomes of Monteggia fractures have been poor due to inadequate means of obtaining and maintaining ulnar and radial head reduction [5–9]. Improvements in methods of internal fixation combined with a better understanding of the components of the injury pattern as it relates to elbow stability have allowed surgeons to achieve better outcomes than their predecessors [11–14] (Table 7.1). In general, posterior Monteggia fractures that are associated with coronoid or radial head involvement tend to have worse outcomes [10–12].

Ring et al. reported on one of the largest series of Monteggia fractures in adults treated with modern internal fixation devices [11]. The authors were able to compare results of posterior and anterior Monteggia injuries [11]. Although 83 % of the study population eventually had satisfactory outcome, reoperations and complications were high. In particular, they noted a 50 % unsatisfactory result after index operation in posterior Monteggia injuries with associated radial head fracture. Overall, nine (24 %) of their patients required reoperation within 3 months, 16 % of whom were for loss of ulna fixation and 8 % for secondary radial head resection. The method of fracture fixation was variable in their study and ranged from tension-band wiring to fixation with plates placed along the medial, lateral, or dorsal cortex of the ulna. Loss of fracture fixation was highest in injuries treated with tension-band wiring or plate fixation placed on the medial or lateral cortex of the ulna and lowest in patients treated with 3.5 mm contoured plates along the dorsal ulna. The authors highlighted several points about treatment: (1) posterior Monteggia injuries commonly happen in older females with osteoporotic bone and require stout fixation, (2) contoured plates placed along the dorsal ulna allow for improved fixation in the proximal ulna with more screws overall and more screws oriented perpendicular to one another when compared with medial or lateral plate placement, (3) coronoid involvement necessitates stable reconstruction of the trochlear notch, and (4) radial head fractures increase the likelihood of an unsatisfactory result.

Similarly, Konrad et al. reported long-term outcomes in a series of Monteggia fractures in adults and confirmed that radial head fractures, fractures involving the coronoid and posterior

Table 7.1 Outcomes of posterior monteggia fracture dislocation

Publication	Ring et al. JBJS 1998	Konrad et al. JBJS Br 2007	Beingessner et al. JOT 2011	Doornberg et al. CORR 2004
Patients	38[a]	37[a]	16	16[a]
Follow-up	6.5 years (2–14)	8 years (5–11)	37 weeks (9–82)	6 years (3–10)
Age	58 years (27–88)	43 years (21–72)	–	53 years (21–82)
Gender	15 male, 23 female	18 male, 9 female	–	8 male, 8 female
Injury characteristics				
Open fracture	3 (8 %)—2 type I, 1 type IIA	4 (11 %)—unspecified	5 (6 %)	1 (6 %)
Radial head fracture	26 (68 %)—7 type 2, 19 type 3	11 (30 %)—unspecified	15 (94 %)—unspecified	13 (81 %)—3 type 2, 10 type 3
Coronoid fracture	10 (26 %)	11 (30 %)	14 (88 %)—5 type 1, 1 type 2, 8 type 3	16 (100 %)—1 type 2, 15 type 3
LUCL involvement	–	–	2 required repair	2 required repair
Neurologic injury	0 (0 %)	3[a]	0	1 (6 %)—brachial plexus palsy
Other injuries	3—distal radius fx	–	1/3—unspecified	2 (12 %)—distal radius fx
	1—floating elbow			1 (6 %)—shoulder dislocation
	1—proximal humerus fx			
	1—shoulder dislocation			
	2—compartment syndrome			
Method of fixation	3—tension band wiring	11—tension band wiring	16—3.5 LC-DCP with mini-fragment plate supplemental fixation	11—3.5 mm LC-DCP
	1—Steinmann pin	26—3.5 mm DCP or LC-DCP		2—3.5 mm DCP
	17—3.5 mm DCP			1—3.5 mm recon plate
	10—3.5 mm LC-DCP			1—tension band wiring
	2—3.5 mm recon plate			
	4—semitubular plate			
Avg. Arc ROM (extension-flexion)	112 (range: 65–140)	103 (range: 50–130)	101	95 (50–125)
Avg. Arc ROM (pronation-supination)	126 (range: 0–160)	128 (range: 100–180)	139	115 (0–170)
Broberg-Morrey score	Excellent—14 (37 %)	Excellent—8 (30 %)	–	Excellent—5 (31 %)
	Good—18 (47 %)	Good—9 (33 %)		Good—7 (44 %)
	Fair—1 (3 %)	Fair—6 (22 %)		Fair—1
	Poor—5 (13 %)	Poor—4 (15 %)		
ASES	–	–	–	78 (28.5–100)
DASH score	–	22 (0–70)	–	–
Reoperation	9 (24 %)—6 (16 %) loss of fixation, 3 (8 %) for secondary radial head resection	12 patients of entire study group (26 %)—6 nonunion, 2 infection, 2 radial head loss of fixation, 2 synostosis	1 (6 %)—removal of hardware	–
Arthrosis	3 (8 %)	–	0 (0 %)	9 (56 %)
Other complications	2 (5 %)—synostosis	5 (14 %)—heterotopic ossification	3 (19 %)—heterotopic ossification	3 (18 %)—synostosis
	1 (3 %)—PLRI	2 (5 %)—synostosis	1 (6 %)—radial head malunion	
			1 (6 %)—late median and radial nerve compression	

LC limited contact, *DCP* dynamic compression plate, *PLRI* posterolateral rotatory instability
[a]Part of larger study

Monteggia fracture patterns portended worse outcomes as compared with anterior Monteggia injuries [12]. Reoperation (26 %) was common and was performed for either: ulnar nonunion (13 %), infection (4 %), radial head malunion (4 %), and synostosis resection (4 %). Although 30 % of the ulna fractures were treated with tension band wiring, the authors noted that this technique was only utilized in simple fracture patterns without significant comminution. They also commented that using a dorsal countoured plate provides improved fracture stability.

Beingessner et al. described their recommended surgical technique and outcomes of treating the posterior Monteggia injuries with comminution extending from the ulna diaphysis to the olecranon (Jupiter IID) [14]. The methods of ulna fixation were more uniform and employed a combination of mini-fragment plates to reconstruct the ulna in a step-wise fashion in conjunction with a long 3.5 mm plate placed along the dorsal ulna and contoured around the olecranon. They experienced no incidence of loss of fixation of the ulna in their patients and the reoperation rate was low (6 %).

Utilizing the Broberg-Morrey scale for outcomes, good to excellent outcomes may be achievable in 63–84 % of patients when utilizing contemporary means of internal fixation [11–13, 37]. The average flexion-extension arc of motion achievable ranges between 95 and 112° and the average pronation-supination arc of motion ranges between 115 and 128° [11–14]. The observed rate of ulnohumeral arthrosis ranges from 0 to 56 % and is dependent upon whether the fracture extends proximally to involve the coronoid and trochlear notch as well as length of follow-up in the reported studies [11–14]. Proximal radioulnar joint synostosis and heterotopic ossification range from 5 to 19 % of cases and correlate with poorer patient outcomes [11–14].

Reoperation rates range from 6 to 26 % and may be attributable to loss of ulna fixation, ulna nonunion, radial head malunion or loss of fixation, infection, synostosis or heterotopic ossification removal and symptomatic hardware [11–14]. The most commonly reported reasons for reoperation were related to either loss of ulna fixation or secondary procedures for radial head fracture, highlighting the importance in achieving stable anatomic reconstruction of the ulna and in choosing the optimal initial management of any associated radial head fracture [11–14]. Most of the secondary procedures performed on the radial head were due to loss of fixation or malunion of comminuted Mason Type III fractures treated with open reduction and internal fixation. In most cases, the secondary treatment for these complications involved radial head resection to improve forearm pronation-supination. However, in the acute setting radial head arthroplasty may be preferable to radial head resection due to the secondary stabilizing effect of the radial head on elbow stability [19–22, 38].

Ring et al. reported on outcomes of revision surgery for loss of alignment of 17 posterior Monteggia fractures [32]. The initial loss of alignment in this series of patients was often due to technical errors in methods of fixation (i.e., utilizing tension-band wires or intramedullary screws or with plates being placed either medial or lateral) or failure to address all components of the injury pattern (i.e., coronoid fractures, lateral ulnar collateral ligament injuries). The fractures were revised with 3.5-mm contoured plates placed along the dorsal ulna cortex and a variety of procedures to address the radial head, lateral ulnar collateral ligament, or heterotopic ossification. Lateral ulnar collateral ligament repair was required in four (24 %) of patients and hinged external fixation was utilized in five (29 %) to protect the internal fixation or address residual ulnohumeral instability. Overall, 82 % of their patients achieved a good or excellent result according to the Broberg-Morrey system and flexion-extension arc of motion improved from 58° (range: 30–90) to 108° (range: 75–135), while pronation-supination arc of motion improved from 42° (range: 0–110) to 134° (range: 40–150).

Case Examples

Case 1

A 46-year-old female sustained a posterior Monteggia fracture at the level of the ulnar metaphysis (Jupiter IIB) with associated comminuted

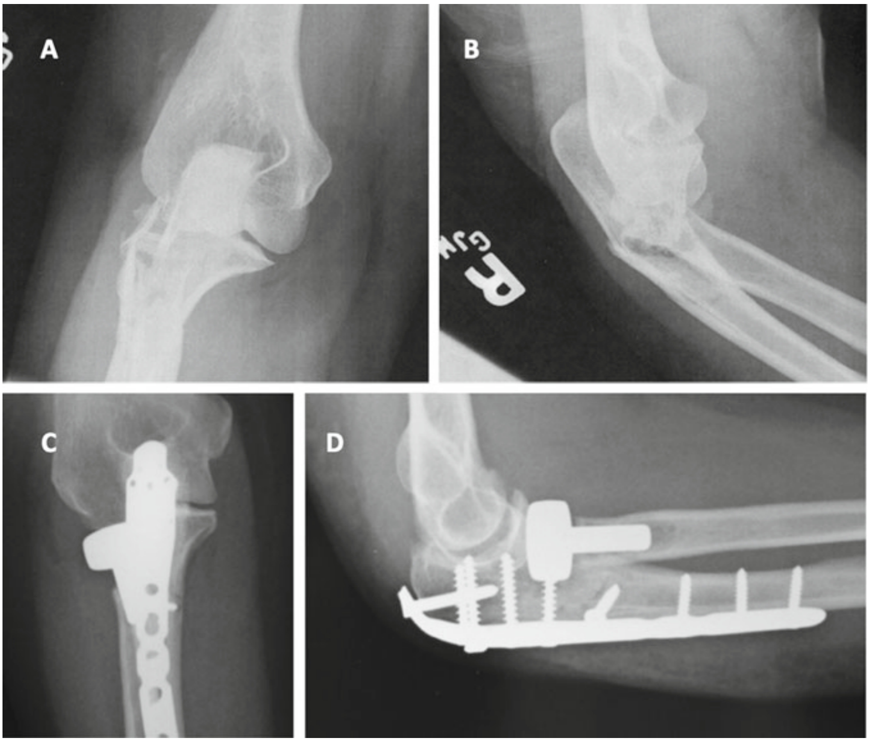

Fig. 7.5 Posterior Monteggia with radial head fracture. Anteroposerior (**a**) and Lateral (**b**) radiographic views demonstrate posterior Monteggia at metaphyseal level (Jupiter IIB) with associated comminuted radial head fracture. Postoperative Anteroposterior (**c**) and Lateral (**d**) radiographic views after stable fixation with posteriorly placed and contoured plate and metallic radial head arthroplasty (From Wong JC, Getz CL, Abboud JA. Adult Monteggia and Olecranon Fracture Dislocations of the Elbow. *Hand Clin*. 2015;31(4):565–80)

radial head fracture (Fig. 7.5a, b). Surgery was performed through posterior approach to elbow. The fracture site and soft-tissue disruption allowed access to perform radial head arthroplasty. After radial head arthroplasty was performed, the proximal ulna was reconstructed with a combination of inter-fragmentary screw and posteriorly applied pre-contoured 3.5 mm olecranon plate (Fig. 7.5c, d). At final follow-up the patient regained full range of motion in flexion-extension and pronation-supination, comparable to her uninjured elbow. She had no further reoperations.

Case 2

A 55-year-old male sustained a posterior Monteggia fracture with involvement of the coronoid and extension toward ulnar diaphysis (Jupiter IID) and associated radial head fracture (Fig. 7.6a, b). Fracture fixation was performed through posterior approach. The ulnar nerve was identified and protected for subcutaneous transposition at the end of the case. Wide medial and lateral skin flaps permitted access to either side of the joint. A Kocher approach to the radial head also permitted assessment of lateral ulnar collateral ligament integrity. The radial head fracture fragment could not be fixed with screws so fixation was achieved with K-wires. In this case, the lateral ulnar collateral ligament did not require repair; however if necessary the lateral ulnar collateral ligament can be repaired with a suture anchor placed at the isometric point on the lateral epicondyle. Proximal ulna was reconstructed with a combination of inter-fragmentary screws and posteriorly applied 3.5 mm plate. As is characteristic of Jupiter Type IID Monteggia

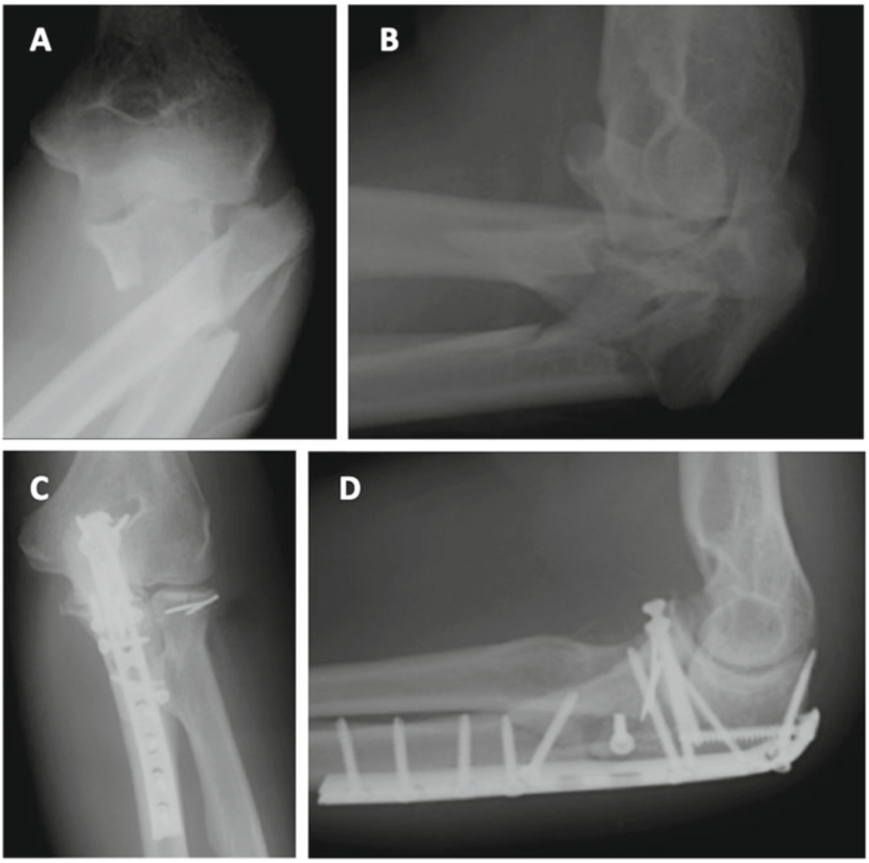

Fig. 7.6 Posterior Monteggia with coronoid involvement. Anteroposterior (**a**) and Lateral (**b**) radiographic views demonstrate a posterior Monteggia fracture with characteristic large anterior quadrangular ulnar fragment extending into the coronoid process as well as radial head fracture. Anteroposterior (**c**) and Lateral (**d**) radiographs after anatomic reduction and fixation of the ulna with posterior placed plate and screws. Supplemental fixation of the large anterior ulna fragment with anterior-to-posterior directed screws. The radial head fragment is fixed with k-wires (From Wong JC, Getz CL, Abboud JA. Adult Monteggia and Olecranon Fracture Dislocations of the Elbow. *Hand Clin*. 2015;31(4):565–80)

fractures, the coronoid fracture fragment extended into the ulnar shaft. In this case, adequate fracture reduction and fixation could not be achieved indirectly so the decision was made to gain direct visualization of that fragment through a medial approach. The medial skin flap was elevated to allow flexor-pronator elevation and the coronoid fragment was fixed with anterior-to-posterior inter-fragmentary screws (Fig. 7.6c, d). In complex fractures of the proximal ulna associated with coranoid process fractures that require fixation, the Taylor-Scham approach offers an extensile approach allowing access to all components of the injury (see Chap. 3). At final follow-up the patient regained 5–100° of motion in extension-flexion and near-full pronation-supination.

Summary

Posterior Monteggia fractures are complex injuries that occur more commonly in adults and often times in older females with osteoporotic bone. Associated injuries such as radial head fracture, coronoid fracture, lateral ulnar collateral ligament injury, and ulnohumeral instability are common and must be addressed. Good outcomes can be achieved if the surgeon recognizes the pattern of injury and the influence that the each of the associated injuries has on elbow stability. The most stable method of fixation of the ulna involves a 3.5-mm plate placed along the dorsal cortex and contoured around the olecranon. When the fracture extends proximally into the coronoid or olecranon, then stable reconstruction of the trochlear notch is required. Concomitant radial head fractures may be managed in a variety of ways depending upon fracture displacement and comminution. For comminuted radial head fractures, strong consideration should be given toward radial head arthroplasty as opposed to repairing or resecting the radial head. Lateral ulnar collateral ligament injuries may require repair if ulnohumeral stability persists despite anatomic ulna and radial head reconstruction. Complications like stiffness, posttraumatic arthrosis, heterotopic ossification, and synostosis are common and may require subsequent procedures to address.

References

1. Bado JL. The Monteggia lesion. Clin Orthop Relat Res. 1967;50:71–86.
2. Ring D, Waters PM. Operative fixation of Monteggia fractures in children. J Bone Joint Surg Br. 1996; 78(5):734–9.
3. Ring D, Jupiter JB, Waters PM. Monteggia fractures in children and adults. J Am Acad Orthop Surg. 1998;6:215–24.
4. Guitton TG, Ring D, Kloen P. Long-term evaluation of surgically treated anterior Monteggia fractures in skeletally mature patients. J Hand Surg Am. 2009;34(9):1618–24.
5. Watson-Jones R. Fractures and joint injuries. 3rd ed. Baltimore, MD: Williams and Wilkins; 1943. p. 520–35.
6. Speed JS, Boyd HB. Treatment of fractures of the ulna with dislocation of the head of the radius (Monteggia fracture). J Am Med Assoc. 1940;115:1699–705.
7. Bruce HE, Harvey Jr JP, Wilson Jr JC. Monteggia fractures. J Bone Joint Surg. 1974;56-A:1563–76.
8. Pavel A, Pitman JM, Lance EM, Wade PA. The posterior Monteggia fracture. A clinical study. J Trauma. 1965;5:185–99.
9. Penrose JH. The Monteggia fracture with posterior dislocation of the radial head. J Bone Joint Surg Br. 1951;33:65–73.
10. Jupiter JB, Leibovic SJ, Ribbans W, Wilk RM. The posterior Monteggia lesion. J Orthop Trauma. 1991;5(4):395–402.
11. Ring D, Jupiter JB, Simpson NS. Monteggia fractures in adults. J Bone Joint Surg Am. 1998;80(12): 1733–44.
12. Konrad GG, Kundel K, Kreuz PC, Oberst M, Sudkaamp NP. Monteggia fractures in adults: long-term results and prognostic factors. J Bone Joint Surg Br. 2007;89(3):354–60.
13. Doornberg J, Ring D, Jupiter JB. Effective treatment of fracture-dislocations of the olecranon requires a stable trochlear notch. Clin Orthop Relat Res. 2004;429:292–300.
14. Beingessner DM, Nork SE, Agel J, Viskontas D. A fragment-specific approach to Type IID Monteggia elbow fracture-dislocations. J Orthop Trauma. 2011;25(7):414–9.
15. Regan WD, Korinek SL, Morrey BF, An KN. Biomechanical study of ligaments around the elbow joint. Clin Orthop Relat Res. 1991;271:170–9.
16. Regan W, Morrey B. Fractures of the coronoid process of the ulna. J Bone Joint Surg Am. 1989;71(9):1348–54.
17. Wilkins KE, Morrey BF, Jobe FW, Kvitne RS, Coonrad RW, Figgie 3rd HE, Jupiter JB, Inglis AE, Wright 2nd PE, Burns EB, et al. The elbow. Instr Course Lect. 1991;40:1–87.
18. Tashijian RZ, Katarinic JA. Complex elbow instability. J Am Acad Orthop Surg. 2006;14(5):278–86.
19. King GJ, Morrey BF, An KN. Stabilizers of the elbow. J Shoulder Elbow Surg. 1993;2(3):165–74.
20. Beingessner DM, Dunning CE, Gordon KD, Johnson JA, King GJ. The effect of radial head fracture size on elbow kinematics and stability. J Orthop Res. 2005;23(1):210–7.
21. Beingessner DM, Dunning CE, Gordon KD, Johnson JA, King GJ. The effect of radial head excision on elbow kinematics and stability. J Bone Joint Surg Am. 2004;86-A(8):1730–9.
22. Johnson JA, Beingessner DM, Gordon KD, Dunning CE, Stacpoole RA, King GJ. Kinematics and stability of the fractured and implant-reconstructed radial head. J Shoulder Elbow Surg. 2005;14(1 Suppl S):195S–201.
23. Closkey RF, Goode JR, Kirschenbaum D, Cody RP. The role of the coronoid process in elbow stability. A biomechanical analysis of axial loading. J Bone Joint Surg Am. 2000;82-A(12):1749–53.
24. Deutch SR, Jensen SL, Tyrdal S, Olsen BS, Sneppen O. Elbow joint stability following experimental osteoligamentous injury and reconstruction. J Shoulder Elbow Surg. 2003;12(5):466–71.
25. Jeon IH, Sanchez-Sotelo J, Zhao K, An KN, Morrey BM. The contribution of the coronoid and radial head to the stability of the elbow. J Bone Joint Surg Br. 2012;94(1):86–92.
26. Schneeberger AG, Sadowski MM, Jacob HA. Coronoid process and radial head as posterolateral rotatory stabilizers of the elbow. J Bone Joint Surg Am. 2004;86-A(5):975–82.
27. Hull JR, Owen JR, Fern SE, Wayne JS, Boardman 3rd ND. Role of the coronoid process in varus

osteoarticular stability of the elbow. J Shoulder Elbow Surg. 2005;14(4):441–6.
28. Ring D. Monteggia fractures. Orthop Clin North Am. 2013;44(1):59–66.
29. Ring D, Jupiter JB. Fracture-dislocation of the elbow. J Bone Joint Surg Am. 1998;80(4):566–80.
30. Mason ML. Some observations on fractures of the head of the radius with a review of one hundred cases. Br J Surg. 1954;42:123–32.
31. Hotchkiss RN. Displaced fractures of the radial head: internal fixation or excision? J Am Acad Orthop Surg. 1997;5(1):1–10.
32. Ring D, Tavakolian J, Kloen P, Helfet D, Jupiter JB. Loss of alignment after surgical treatment of posterior Monteggia fractures: salvage with dorsal contoured plating. J Hand Surg Am. 2004;29(4):694–702.
33. Athwal GS, Ramsey ML, Steinmann SP, Wolf JM. Fractures and dislocations of the elbow: a return to the basics. Instr Course Lect. 2011;60:199–214.
34. Ring D, Quintero J, Jupiter JB. Open reduction and internal fixation of fractures of the radial head. J Bone Joint Surg Am. 2002;84A(10):1811–5.
35. Ring D, Jupiter JB, Sanders RW, Mast J, Simpson NS. Transolecranon fracture-dislocation of the elbow. J Orthop Trauma. 1997;11(8):545–50.
36. Ring D, Hannouche D, Jupiter JB. Surgical treatment of persistent dislocation or subluxation of the ulnohumeral joint after fracture-dislocation of the elbow. J Hand Surg Am. 2004;29(3):470–80.
37. Broberg MA, Morrey BF. Results of treatment of fracture-dislocations of the elbow. Clin Orthop Relat Res. 1987;216:109–19.
38. Harrington IJ, Sekyi-Out A, Barrington TW, Evans DC, Tuli V. The functional outcome with metallic radial head implants in the treatment of unstable elbow fractures: a long-term review. J Trauma. 2001;50(1):46–52.