

Monteggia Fractures in Adults

Monteggiova zlomenina dospělých

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SUMMARY

Over the past fifty years, treatment outcomes of traumatic injuries in the upper limb have improved with the advent of better implants. However, the Monteggia fracture is often still associated with various complications, poor functional outcomes and a relatively high rate of revision surgeries. Rigid anatomic fixation of ulnar fracture is paramount. Open relocation of the radial head and soft tissue procedures are redundant.

Monteggia fractures are challenging to treat. Critical analysis with respect to the high rate of complications and unsatisfactory functional outcomes is required. The type of fracture and associated injuries such as coronoid fracture and radial head fracture appear to influence the outcome in most cases. Negative prognostic factors such as prolonged immobilization, associated coronoid and radial head fractures must be minimized and treated appropriately. Prior to surgery the patient should be informed regarding the possible risk of residual functional limitations and the potential need for further revision surgeries.

INTRODUCTION

Giovanni Battista Monteggia (1762–1815) first described the Monteggia fracture in 1814 and defined the primary characteristics of a “traumatic fracture distinguished by a fracture of the proximal third of the ulna and an anterior dislocation of the proximal epiphysis of the radius” (3). The modern definition of the Monteggia fracture may include any fracture of the forearm with dislocation of the proximal radioulnar joint. The incidence of this type of fracture varies between 1 to 2% of all forearm fractures (24).

The gold standard for the treatment of Monteggia fractures in adults continues to be immediate recognition, stable, anatomic fixation of the ulna fracture and early mobilization. Over the years, additional injuries such as radial head fracture, coronoid fracture, and combined radial head and coronoid fracture have resulted in confusion in exploring Monteggia-related injuries.

Morphology and pathoanatomy of the Monteggia fracture

The forearm plays an essential role in the integrated function of the upper limb. Normal forearm functioning requires intact skeletal structures, including a stable proximal and distal radio-ulnar joint, a normal interosseus ligament, intact muscles, ligaments, and tendons. Three main anatomic structures in the forearm ensure its longitudinal stability: the radial head, the interosseus ligament (mainly the central band), and the palmar and dor-

sal radioulnar ligaments of the triangular fibrocartilage complex (TFCC) (6, 14).

The ulna and radius are of nearly equal length (10). Several studies have examined dynamic modeling of the human forearm (2, 5). The longitudinal axis of rotation of the forearm has been shown to pass through the articular surface of the radial head, the interosseus ligament, and the articular surface of the ulna at the distal radioulnar joint (18).

While annular and quadrate ligaments are ruptured in a Monteggia fracture which causes a dissociation of the radiocapitellar joint and proximal radial ulnar joint (PRUJ), the greater portion of the TFCC and the interosseus membrane remain intact. These two structures ensure that anatomic reduction of the ulnar fracture will restore the congruity of the PRUJ and the radiocapitellar articulation, respectively (7).

It is obvious that during pronation, maximum contact exists between the radial head and the capitellum with minimum tension in the interosseus ligament. This is followed by a slight anterior translation of the radial head on the capitellum. Patients with a Monteggia fracture dislocation often report a fall on a pronated and flexed arm or imminent blow to the ulna. The range of motion of the elbow joint and forearm supination are often restricted. Hence, the radial head is overloaded by the total force transfer and the anterolateral segment of the radial head is usually fractured. It is well known that the radial head fracture occurs in a comminuted pattern, resulting in acute migration of the radius with subsequent tearing of the interosseus ligament (1, 19).

Clinical and radiographic evaluation

Pain, swelling, and loss of function of the hand and forearm, as well as local tenderness, are the main indicators for the diagnosis of a fracture. A precise neurologic and vascular examination of the upper limb is crucial. Although uncommon, posterior interosseus nerve lesions occur more often in patients with associated fractures of the radial head and in patients with posterior Monteggia-type fractures. The skin covering the forearm should be inspected for lacerations, abrasions, and any signs of injury. Perfusion of the upper limb can be tested by palpation of the pulses and assessment of capillary refill. Motor and sensory testing of radial, ulnar, and median nerves must be performed and carefully documented. Related proximal or distal joint disorders of the forearm should be carefully excluded. Ultimately, radiographic examination of the forearm in two different planes as well as anterior/posterior and lateral X-rays of the wrist and elbow will determine the proper diagnosis and fracture classification. CT scans might also be necessary to evaluate the severity of existing proximal-distal radioulnar joint injuries. A 45-degree radial head oblique view on CT will evaluate the radial head and help differentiate this structure from the ulna. Patients present with pain and swelling at the elbow. A tense swelling of the upper limb and severe postoperative pain are indicative of compartment syndrome.

A timely intervention could be facilitated by paying special attention to the normal radiocapitellar anatomy, which can be identified on an X-ray of the elbow. If the radial head is properly positioned, a line down the center of the shaft and head of the radius may anatomically intersect the capitellum in all directions of flexion/extension, in any dimension (Stoeren-Line). When the apex of the ulnar fracture points in the direction of the radial head dislocation, a Monteggia fracture can be diagnosed (16).

However, not all radiocapitellar dislocations indicate a Monteggia fracture. Transolecranon fracture-dislocation of the elbow also verifies a radiocapitellar dislocation, despite differential anterior dislocation of the elbow (26).

Classification

The Arbeitsgemeinschaft der Osteosynthese Fragen (AO) group classification of forearm fracture takes precedence over all other conventional classification systems and has also been adopted by the Orthopaedic Trauma Association (OTA) (21). However, the Bado and Jupiter classifications have been applied more frequently in the literature due to considerations of surgical practicality (Table 1). In 1967, Bado classified Monteggia fractures as one of four types depending on the direction of the radial head's dislocation and the angulation of the ulnar fracture. In the type I Monteggia fracture, the dislocation is anterior, in type II, posterior, and in type III, lateral. Type IV is defined as a fracture of both bones of the forearm with dislocation of the radial head (Fig. 1a–d).

The mechanism of injury is mainly determined by the direction of radial head dislocation and is helpful in choosing the appropriate reduction maneuver and cast positioning (3). The type II Monteggia fracture has been divided by Jupiter into four subgroups (13). Monteggia-like fracture includes additional injuries such as radial head fractures (Mason, grade I–IV) and coronoid fractures (Regan and Morrey I–III). Radius head luxation is often associated with radial shaft, radial neck, and radial head fractures (Bado I–III and Masson I–IV).

Posterior Monteggia fracture

Pattern of injury

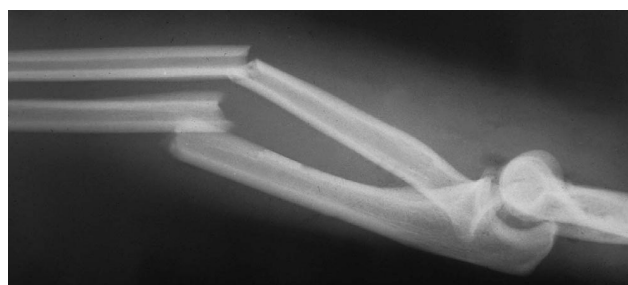
Recognition of the injury pattern is as important as detection of the radial head dislocation. Compared to transolecranon fracture in the posterior Monteggia fracture, malfunction occurs mainly in the proximal ulna rather than in the collateral ligaments or capsular structures of the ulnohumeral articulation (Fig. 2a, b) (23).

Surgical technique

A dorsal approach to the ulna is performed with the patient in the supine position. The injured hand is placed on a hand table. A tourniquet is applied to the upper arm. Once a dissection has been made the fracture has to be anatomically reduced; special care must be taken to restore the anatomical configuration. Using a 1.6 mm K-wire and lag screw stabilizes the fracture momentarily. In order to stabilize the fracture a contour plate is placed on the dorsal side ("tension side") of the ulna. Then the most proximal screw is inserted at 90 degrees to the more distal cortex screws. Lag screws help to stabilize a fractured coronoid fragment (12). In the majority of cases, ulnar reduction aids with proper reduction of the radial head. As stated by AO, malreduction of the ulna often results in radial head dislocation. In cases of multiple fragmental fractures of the proximal ulna, the thorough examination necessary for an accurate anatomo-

Table 1. Monteggia fracture classification by Bado and Jupiter (3, 13).

| Bado | Jupiter | Morphology |
|----------|---------|---|
| Type I | | Fracture of the ulnar diaphysis at any level with anterior angulation at the fracture site and an associated anterior dislocation of the radial head. |
| Type II | | Fracture of the ulnar diaphysis with posterior angulation at the fracture site and a posterolateral dislocation of the radial head. |
| A | | Fracture of the ulna involves the distal part of the olecranon and the coronoid process. |
| B | | Fracture is at the metaphyseal-diaphyseal juncture, distal to the coronoid process. |
| C | | Fracture is diaphyseal. |
| D | | Fracture extends to the proximal half of the ulna. |
| Type III | | Fracture of the ulnar metaphysis with a lateral or anterolateral dislocation of the radial head. |
| Type IV | | Fracture of the proximal third of the radius and ulna at the same level with an anterior dislocation of the radial head. |



a | c
b | d

Figs. 1a-d. Bado and Jupiter classification of Monteggia fracture: Type II A-B-C-D. A lateral view of type IIA fracture, which involves the distal part of the olecranon and the coronoid process (a); a lateral view of type IIB fracture shows the fracture located at the metaphyseal-diaphyseal juncture, distal to the coronoid process (b); a lateral view of type IIC fracture shows the fracture, which is diaphyseal located (c); a lateral view of type IID fracture shows the fracture extended to the proximal half of the ulna (d).

mical realignment of the ulna can be difficult. In this case an AP and lateral X-ray of the elbow and proximal forearm may exclude a dislocation or luxation of the radius (21).

Postoperative management

On the first or second postoperative day, range of motion exercises are recommended to alleviate postoperative stiffness. In order to avoid varus/valgus stress

at the ulnohumeral joint, a hinged brace is recommended (12). Another potential complication is heterotopic ossification (HO), including synostosis of the proximal parts of the radius and ulna. Due to insufficient data a regular administration of nonsteroidal anti-inflammatory drugs cannot be recommended at the moment. In severe cases intraoperative radiation and postoperative indomethacin administration can help to minimize the formation of any ossification. **Pitfalls:** Surgical complications may include the entire range of possibilities: an injury of the posterior interosseous nerve, malunion of the ulna, radial head subluxation, synostosis of the radius-ulna, a loss of elbow motion, incomplete radial head reduction, fixation of the ulnar metaphysis in flexion and plate application along the side of the ulna. **Plate application along the side of the ulna:** Positioning of the plate on the medial side induces dorsal angulation of the ulna. This leads to dorsal subluxation of the radius. **Pearls:** Positioning the plate on the dorsal side of the ulna improves the biomechanical properties of the implant (by tension band-plating the ulna) (12) (Fig 3), avoids devascularization of comminuted fragments, and controls mobilization (e.g. continuous passive motion (CPM)). This technique facilitates stable anatomic fixation of the ulna, secure fixation of coronoid fractures, detection of posterolateral instability, and appropriate treatment of radial head fracture through a separate muscular interval. Restoring the ulnar length in a comminuted fracture may necessitate

a | b



Figs. 2a-b. Lateral views of a displaced type II Monteggia fracture: radial head fracture, coronoid fracture, posterolateral rotatory instability (a); lateral view of an ORIF stabilized displaced type II Monteggia fracture, average follow up 32 months (b).

the application of a distracter device for indirect reduction. This will ensure thorough stripping of the periosteum and of adjacent musculature from the bone. While a 3.5-mm Schanz pin is positioned across the olecranon fragment into the distal humerus with the elbow flexed to 90 degrees, another Schanz pin is positioned in the distal shaft of the ulna. Once the distraction is performed and ulnar length is restored, the plate can be fixed to the ulna and the distracter will be removed. The plate must cover the proximal ulna. This will enable the insertion of more screws in the proximal fragment and will stabilize the construct. Once a provisional plate has been fixed in place, it is necessary to confirm correct anatomic reduction of the ulna and radiocapitellar alignment via image intensifier (7, 26). **Bone graft:** Until now autogenous cancellous bone grafting has been recommended for most Monteggia fractures in adults. Currently, the benefit of bone grafting is considered to be controversial (30, 31).

Chronic adult Monteggia fracture

An unreduced Monteggia fracture with persistent angulation of the ulna can cause a chronic dislocation of the radial head. Due to angulated metaphyseal malunion of the proximal radius a distinct incongruity of the radial head in the sigmoid notch is present. This incongruity severely limits pronation. In most cases a neglected Monteggia fracture or a mal-reduced ulnar fracture results in ulnar shortening. This is often a major cause for chronic dislocation of the radial head (Fig. 4). Despite several negative long-term prognostic effects such as weakness, instability, pain, and proximal migration of the radius, excision of the radial head has been advocated for treatment of chronic adult radial head dislocation. In order to reduce the frequency of poor outcomes related to the excised radial head, in 2006, Jepeganm performed a relocation of the radial head and ulnar osteotomy in four chronic adult Monteggia fractures. Initially he overcorrected the fracture, which resulted in "mild dorsomedial angulation". This was followed by fixation with plates and 3.5-mm AO screws. First the proximal screws were positioned through the pre-con-

toured plate. Second the ulna was lengthened by applying distal screws in a distraction manner. An immobilization in semisupination for 6 weeks was recommended. After 24 months of follow up, three patients had improved range of motion and supination. All four patients complained about considerable loss of pronation (11). Contrary to Jepeganm we prefer a shortening of the radius to a lengthening of the ulna. This procedure not only shortens the operating time, but also has a better morbidity index for the patient.

First, an ORIF of the radial head is performed; this is followed by a shortening of the radius. Then, we expose the elongated capsule of the lateral elbow compartment between the brachioradialis and brachialis muscle. Detachment of the supinator muscle helps with visualization of the posterior interosseus nerve. Once the radius is shortened the plate is provisionally fixed via 2 screws to the proximal fragment. Then, the preset transverse segment of the bone is disconnected and the plate is permanently fixed. After a proper shortening of the radius length is completed the radial head reduces spontaneously. Repair of an annular ligament is not necessary if the radial head remains reduced, which is determined through passive examination of the range of motion. Long-term follow up of both procedures is necessary; the results remain to be seen.

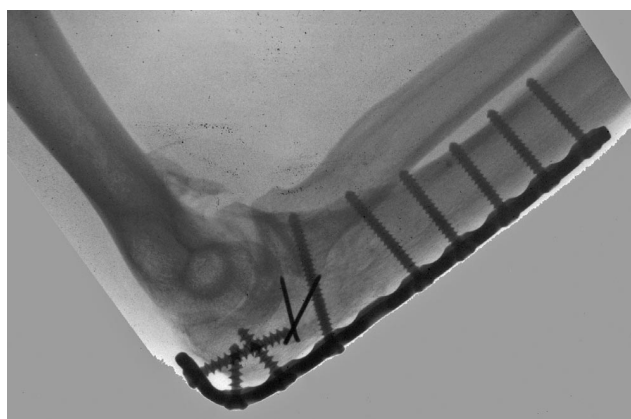


Fig. 3. Lateral view of a displaced Monteggia fracture. Pearls: tension band plating ulna, bone graft.

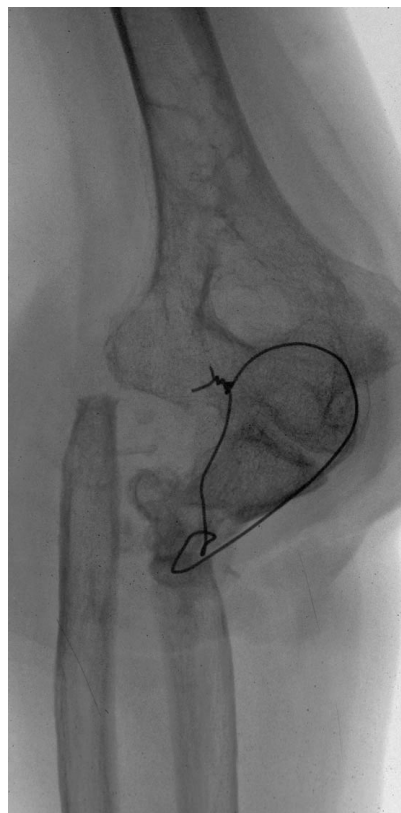


Fig. 4. Anteroposterior view of a chronic radial head subluxation. A neglected Monteggia fracture resulted to an ulnar shortening. This is often a major cause for chronic dislocation of the radial head.

Outcomes, controversies and trends for the future

Ironically, despite surgical advancements over the last 50 years, Watson-Jones's comment on dealing with Monteggia fracture has still some truth in it. He stated that "no fracture presents so many problems; no injury is beset with greater difficulty; no treatment is characterized by more general failure." Today the dilemma with Monteggia fracture results more from the performance errors of clinical studies rather than a lack of surgical expertise (29). Numerous articles concerning Monteggia fractures have been published over the years. However, the reports have largely failed to limit and specify their inclusion groups and have grouped together adult and pediatric populations despite differences in surgical approaches, injury patterns and outcomes (3, 9, 13, 27, 28). Acute and chronic injuries have been mixed together. Transolecranon fracture dislocations have not been excluded (3, 4, 20). Many studies on the outcome of open reduction and internal fixation of the radial head do not reflect the clinical outcomes, since they do not distinguish between those that would have reduced spontaneously with ulnar reduction and those that were technically irreducible (4, 17, 27). While some authors often included transolecranon fracture dislocations, other did not differentiate between Monteggia and Monteggia equivalent or variant fracture dislocation (3, 8, 22–25). The true incidence of Monteggia remains to be determined. In 2007, Konrad et al. performed a retrospective analysis following an average follow-up duration of 8.4 years. Their main purpose was to correlate the Bado and Jupiter classifications with long-term outcomes. The factors that were correlated with a poor clinical outcome included posterior Monteggia fracture-dislocations (Bado type II), fractures involving the olecranon and coronoid (Jupiter type IIa), fractures of the radial head, coronoid fractures, and complications requiring revision (15). In 1999, Wei et al. performed a database search to identify all acute diaphyseal forearm fractures presenting to urban Level I trauma centers between 1988 and 1996. Radius and/or ulnar shaft fractures, Monteggia and Galeazzi fracture-dislocations were integrated in the analysis. The authors determined that immediate bone grafting of diaphyseal forearm fractures did not influence the union rate or the interval to union (30). Currently, the benefit of bone grafting remains to be determined, particularly with regard to the availability of smaller (3.5 mm) LC-DCP plates and customized exposure techniques such as extraperiosteal, indirect reduction, designed to preserve the vascular supply to the fracture fragments. Hence, an appropriate reduction technique that does not compromise the vascular supply, accurately positions the plate, in combination with increased attention to stability and soft tissue preservation, will preclude any further application of bone grafting in the future.

CONCLUSION

Monteggia fractures are uncommon injuries. Complications such as stiffness, malunion, nonunion, syno-

stosis, subluxation or dislocation of the radial head, infection, heterotopic ossification, compartment syndrome and posterior interosseus nerve palsies are common following Monteggia fractures. Early recognition of the injury and dorsal plating of the proximal ulna with relocation of the radial head accompanied by early mobilization are the key factors to ensure long-term clinical success. Once a Monteggia fracture is missed, long-term disability and pain result. Hence the Monteggia fracture concept should be based on maximizing outcomes by minimizing pitfalls. Long-term results of Monteggia fractures are not well-documented in the literature. There must be an international consensus on the inclusion criteria for study subjects, such as a distinct type of fracture, population age, and the differentiation of chronic fractures and acute fractures.

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