

Forearm Shaft Fractures (including Monteggia and Galeazzi)

Overview

- Isolated fractures of the radial diaphysis are more common than true Galeazzi fractures [3].
- Treatment of adult diaphyseal fractures of the forearm with open reduction and plate fixation is considered the standard against which all other treatments are now compared [19].
- The evolution of operative and nonsurgical treatment techniques for forearm diaphyseal fractures highlights a transition from nonsurgical methods with high complication rates to plate osteosynthesis as the surgical treatment of choice after World War II [28].
- Internal fixation by plating is a satisfactory method of treatment for adult forearm fractures, leading to excellent results in a majority of patients [33].
- Results of surgical fixation for adult diaphyseal both-bone forearm fractures have been good, with only modest losses of forearm strength and rotation [29].
- Patients with open fractures and those with fractures of both bones lost significantly more rotation of the forearm, irrespective of treatment [10].
- Optimal outcomes in the treatment of forearm fracture–dislocations depend on early recognition and management, with restoration and maintenance of anatomic alignment being the key principles [11].
- Galeazzi injuries are unstable fracture dislocations requiring surgical management to achieve optimal outcomes [65].
- Long term follow-up is absolutely necessary to monitor ulnar growth in Galeazzi-equivalent fractures [4].
- Intra-medullary pinning of the radius in Galeazzi fractures gives good results compared to plate osteosynthesis [26].
- An excellent clinical result was obtained in a case of radial head dislocation with radial shaft fracture by adhering to the basic principles learnt from the management of Monteggia and other proximal forearm fractures [1].
- It is unusual to sustain two Monteggia fractures of the same forearm, with no such case found in a review of the literature [5].
- Surgical intervention in neglected diaphyseal forearm fractures leads to a satisfactory outcome [2].
- Closed nailing can be treatment of choice in any forearm shaft fractures [7].

- Treatment of adult forearm diaphyseal fracture with new intramedullary nails has promising results [8].
- The results of locking compression plates and dynamic compression plates for treatment of fractures of the forearm in adults are similar [25].
- Treatment plans for forearm fracture should take into consideration the impact of bone atrophy long after plate fixation [27].
- Both surgical and nonsurgical management of isolated ulnar shaft fractures are reported as acceptable forms of treatment with high union rates and good functional outcomes [15].
- In isolated ulnar shaft fractures, essentially no immobilization allows rapid healing with a lower rate of loss of forearm motion compared to literature reports [9].
- The majority of isolated fractures of the ulnar shaft can be treated adequately by closed means, and the use of short casts is recommended [18].
- In the osteoporotic patient, an isolated fracture of the ulnar shaft is perhaps most safely treated in a long arm cast [6].
- Although most ulnar shaft fractures heal successfully with nonsurgical management, a substantial percentage of these fractures do not [24].
- Clinical studies continue to yield contradicting results, and retrospective studies are not able to solve the debate on the optimal treatment of isolated ulnar shaft fractures [16].
- Expert consensus was reached generating a comprehensive list of 26 assessment parameters that can be used to assess surgeon performance in open reduction and internal fixation of an isolated adult ulnar shaft fracture [41].

Anatomy & Pathophysiology

FOREARM FUNCTION AND BIOMECHANICS

- The forearm positions the hand in space through elbow and wrist flexion/extension and pronation/supination via the proximal and distal radioulnar joints [17].
- Inadequate treatment of ulnar and radial shaft fractures can result in significant forearm dysfunction [17].
- Individualized kinematic modeling of forearm malunions reliably detects clinically relevant limitations of forearm rotation without requiring dynamic imaging [51].
- The chapter on forearm fractures emphasizes the importance of restoring radial bow and alignment to maintain forearm rotation [92].

ELBOW JOINT ANATOMY

- The elbow is a trocho-ginglymoid joint with trochoid (rotatory) motion through the radiocapitellar and proximal radioulnar joints and ginglymoid (hinge-like) motion through the ulnohumeral joint [78].
- The ulnohumeral joint allows flexion and extension, while the radiocapitellar joint allows forearm rotation [75].

- The normal range of elbow flexion/extension is 0 to 150 degrees [73, 74].
- Normal forearm pronosupination is 80 to 85 degrees in each direction [73, 74].
- Functional range of motion for the elbow is 30 to 130 degrees of flexion/extension and 50 degrees of pronosupination [73, 74].
- In full extension, 60% of axial load is transmitted through the radiocapitellar joint [73, 74].
- The articular surface of the distal humerus is angled 30 degrees anterior to the humeral shaft axis [73, 74].
- The trochlea articulates with the ulna within the greater sigmoid notch to create the ulnohumeral portion of the elbow joint [67].
- The radial head is a concave elliptical structure that articulates with both the capitellum and the lesser sigmoid notch [67].
- The radius is held in close approximation to the ulna at the proximal radioulnar joint by the annular ligament [67].
- The coronoid process has medial and lateral facets that buttress the trochlea anteriorly [67].
- The sublime tubercle, located just distal and medial to the coronoid, provides the attachment site for the anterior bundle of the medial ulnar collateral ligament [67].
- The distal humeral articulation is angled 30° from the longitudinal axis, and the axis of rotation is 5° to 7° angulated in the coronal plane to the epicondylar axis [67].
- The ulna medially bends approximately 8° at 8 cm from the tip of the olecranon [67].
- The articulation to the tip of the coronoid is approximately 30° from the long axis of the ulna in the sagittal plane [67].
- The medial column of the distal humerus diverges from the humeral shaft at a 45-degree angle, and the lateral column diverges at a 20-degree angle [75].
- The trochlea has a 300-degree arc of cartilage [75].
- The radial head lines up in its lesser sigmoid notch with the annular ligament surrounding it [75].
- The brachialis is the strongest elbow flexor and attaches to the coronoid 11 mm distal to the tip [68, 69].
- The biceps brachii inserts at the ulnar margin of the radial tuberosity and acts as a powerful supinator of the forearm [68, 69].
- The primary elbow extensor, the triceps, inserts on the olecranon process [68, 69].

LIGAMENTOUS ANATOMY AND STABILITY

- Elbow stability is determined by primary stabilizers (ulnohumeral articulation, MUCL, LUCL) and secondary stabilizers (radiocapitellar articulation, common flexor/extensor tendons, joint capsule) [48].
- The medial (ulnar) collateral ligament consists of anterior, posterior, and transverse bundles [73, 74].
- The anterior bundle of the medial collateral ligament is the primary restraint to valgus stress within functional elbow range of motion [73, 74].
- The posterior bundle of the medial collateral ligament is the primary restraint to valgus stress with the elbow in maximal flexion [73, 74].

- The lateral ulnar collateral ligament acts as a posterolateral stabilizer [68, 69].
- The lateral collateral ligament complex consists of the radial collateral ligament, the lateral ulnar collateral ligament, and the annular ligament [78].
- The annular ligament attaches to the anterior and posterior margins of the lesser sigmoid notch [78].
- The radial collateral ligament originates from an isometric point on the lateral epicondyle and fans out to attach to the annular ligament [78].
- The lateral ulnar collateral ligament arises from the isometric point on the lateral epicondyle and attaches to the crista supinatoris of the proximal ulna [78].
- The lateral collateral ligament complex functions as an important restraint to varus and posterolateral rotatory instability [78].
- Tensile forces are present at the medial elbow, while compressive forces are present at the lateral elbow [68, 69].
- The capsule allows maximum distension at approximately 70 to 80 degrees of flexion [68, 69].
- The anterior capsule attaches at a point approximately 6 mm distal to the tip of the coronoid [68, 69].

FRACTURE DEFINITIONS AND CLASSIFICATION

- Radial shaft fractures are defined as those occurring between the radial neck proximally and the junction of the metaphysis and diaphysis distally, approximately 3 cm proximal to the distal articular surface [17].
- Ulnar shaft fractures are defined as those occurring between the distal aspect of the coronoid proximally and the ulnar neck distally [17].
- The AO/OTA classification identifies forearm shaft fractures with the number 22 [50].
- In the AO/OTA classification, Type A fractures are simple, Type B are wedge, and Type C are complex (highly comminuted or segmental) [50].
- Monteggia fractures are classified as types A1.3 and B1.3 depending on whether the ulnar fracture is simple or wedged [50].
- Galeazzi fracture dislocations are classified as types A2.3 and B2.3 depending on whether the radial fracture is simple or wedged [50].
- Isolated ulna fractures are classified as stable if they have less than 50% displacement and less than 10 degrees of angulation [50].

PATHOPHYSIOLOGY AND MECHANISMS

- Fracture of the radial shaft is more commonly associated with an ulnar fracture or a distal radioulnar dislocation (Galeazzi fracture-dislocation) than isolated [35].
- The association of a radial shaft fracture with an ipsilateral elbow dislocation has been reported in only seven adults and two children [35].
- Forearm fractures were more common in snowboarders than in skiers, potentially because snowboarders have both feet fixed to the board, requiring them to break a fall with their arms [34].

- The most common forearm fractures in skiers and snowboarders were simple, isolated radial shaft fractures [34].
- Some isolated radial shaft fractures in snowboarders may have been underdiagnosed Galeazzi subluxations [34].
- Problems with the elbow related to fractures of the coronoid process and the radial head remain the most challenging elements in the treatment of Monteggia injuries [43].
- Posterior Monteggia fractures present a complex management problem requiring a balance between ensuring fracture union and preserving elbow function and range of movement [61].
- Severe osseous, soft tissue, and neural trauma affect the functional results of the elbow region in Monteggia fracture-dislocations [95].
- The exact mechanism of injury for Type IV Monteggia fractures is unknown but is assumed to be similar to the Type I injury accompanied by a fracture of the radius [105].
- Three major mechanisms of injury for Monteggia type I lesions have been proposed: direct blow to the posterior forearm, hyperpronation force applied to the outstretched arm, and elbow hyperextension [99].
- In children, relative laxity of the annular ligament allows for Monteggia type I equivalent lesions where the radial head does not dislocate [99].
- The contribution of concavity-compression stability across the radiocapitellar joint to overall elbow stability is demonstrated in rare Monteggia variants with ulnohumeral dislocation despite an intact radiocapitellar joint [103].
- Increasing magnitudes of soft tissue disruption result in greater anterior radial head instability in anterior Monteggia injuries [113].
- With the elbow in valgus alignment, an average of 93% of force applied to the wrist was transferred directly through the radius to the elbow with no appreciable load transfer through the interosseous membrane [114].
- Longitudinal displacement of the radial head causes it to slip out of the annular ligament while the ligament remains intact during Monteggia fractures [118].
- Most major traumatic plastic bowing deformities of the ulna involved rotation rather than bending [122].
- The mechanism causing delayed radial head dislocation associated with malunion of radial shaft fracture involves eccentric torque on the radial head during forearm pronation [126].
- Migration of the radius under loads implies disruption of both the central band and triangular fibrocartilage complex in Galeazzi fracture dislocations [125].
- Anatomic reduction of the ulna is critical to achieving a favorable outcome in Monteggia injuries, as it indirectly reduces the radiocapitellar joint [136].
- Correction of the ulnar deformity with elongation and angulation of the ulna in the opposite direction of the dislocation of the radial head is the most important factor for the reduction and preservation of the radial head in chronic Monteggia lesions [137].
- The direction of radial head dislocation (anterolateral or posterolateral) in lateral Monteggia fractures may depend on the rotational position of the forearm at the time of the primary adduction injury [132].

Classification

GENERAL PRINCIPLES AND DEFINITIONS

- Forearm shaft fractures are classified according to location (proximal, middle, and distal third) or fracture comminution [50].
- Open forearm fractures are classified according to Gustilo's classification and the OTA open fracture classification [50].
- Isolated ulna fractures are classified as stable or unstable, with stable fractures defined as those with less than 50% of displacement and less than 10 degrees of angulation [50].

AO/OTA CLASSIFICATION

- The AO/OTA classification is the most widely used fracture classification for forearm fractures, identified by the number 22 (2 for forearm, 2 for shaft) [50].
- In the AO/OTA system, Type A fractures are simple fractures, Type B are wedge fractures, and Type C are complex (highly comminuted or segmental) fractures [50].
- Type A and B fractures involve either the ulna (types A1, B1), the radius (types A2, B2), or both bones (types A3, B3) [50].
- Type C fractures involve both bones, with a simple fracture of the radius and segmental comminution of the ulna in type C1, a simple fracture of the ulna and segmental comminution of the radius in type C2, and segmental comminution of both bones in type C3 [50].
- Monteggia fracture dislocations in which both the radius and ulna are fractured are classified as type A3.2 or B3.2 [50].
- Galeazzi fracture dislocations in which both the radius and ulna are fractured are classified as type A3.3 or B3.3 [50].
- The utility of the AO/OTA system in the management of forearm fractures is restricted mainly to research purposes due to the complexity of its nomenclature and low reliability [50].

MONTEGGIA CLASSIFICATION

- The Bado classification system distinguishes among four types of Monteggia lesions based on the mechanism of injury, treatment, and results [23].
- Bado Type I Monteggia lesions involve a fracture of the ulnar diaphysis at any level with anterior angulation at the fracture site and an associated anterior dislocation of the radial head [23].
- Bado Type II Monteggia lesions involve a fracture of the ulnar diaphysis with posterior angulation at the fracture site and a posterolateral dislocation of the radial head [23].
- Bado Type III Monteggia lesions involve a fracture of the ulnar metaphysis with a lateral or anterolateral dislocation of the radial head [23].
- Bado Type IV Monteggia lesions involve a fracture of the proximal third of the radius and ulna at the same level with an anterior dislocation of the radial head [23].

- The Jupiter classification captures complex Monteggia injury patterns, including radial head/neck fracture and comminution of the proximal ulna with coronoid involvement, as a subgroup of Bado posterior Monteggia lesions [98].

GALEAZZI CLASSIFICATION

- Galeazzi fracture-dislocations are classified in true GFD, where the distal radioulnar joint is disrupted, and equivalent GFD [96].
- Galeazzi fracture-dislocations are further subdivided in relation to the radial fracture (incomplete and complete) and ulnar injury (true dislocation versus physeal fracture) [96].
- Letts and Rowhani classified Galeazzi fracture-dislocations using the direction of the ulna: volar or dorsal [96].
- Acute Galeazzi dislocations are classified as simple when a reduction can be easily achieved, and complex characterized by irreducibility or unstable reduction [96].
- In the Rettig and Raskin treatment-oriented classification, Type II Galeazzi fractures (middle third, >7.5 cm from midarticular surface) were largely stable after radial shaft fixation alone [14].

Clinical Presentation

GENERAL FOREARM SHAFT FRACTURES

- Fractures of the ulnar and radial shaft can result in significant dysfunction if treated inadequately [17].
- The most common fractures in a 40-year study of skiers and snowboarders were simple, isolated radial shaft fractures [34].
- Forearm fractures were more common in snowboarders than in skiers [34].
- When comparing the 1990s with the 1950s, there is an increase in the incidence of forearm fractures in both genders [32].
- Children under the age of 15 suffered a total of 360 wrist and forearm fractures during the three winter months, with an incidence of 5.9/1000 per year [42].
- The incidence of wrist and forearm fractures in children under 15 during winter months was about half that observed during the remainder of the year (10.7/1000 per year) [42].
- Atypical forearm fractures are probably more common than reported in the literature to date [20].
- All atypical forearm lesions were accompanied by preceding atypical femur fractures [20].
- The frequency of neurological complications concomitant to forearm fractures is noteworthy [40].

MONTÉGIA FRACTURE-DISLOCATIONS

- Bado established a system of classification for Monteggia lesions based on the mechanism of injury, treatment, and results [23].
- Bado's classification distinguishes among four types of Monteggia lesions [23].

CQ HAND + UPPER LIMB

- Type I Monteggia lesions involve a fracture of the ulnar diaphysis at any level with anterior angulation at the fracture site and an associated anterior dislocation of the radial head [23].
- Type II Monteggia lesions involve a fracture of the ulnar diaphysis with posterior angulation at the fracture site and a posterolateral dislocation of the radial head [23].
- Type III Monteggia lesions involve a fracture of the ulnar metaphysis with a lateral or anterolateral dislocation of the radial head [23].
- Type IV Monteggia lesions involve a fracture of the proximal third of the radius and ulna at the same level with an anterior dislocation of the radial head [23].
- Bado included a number of so-called Monteggia equivalent injuries based on the similarity of their proposed injury mechanism [23].
- Most Monteggia equivalent injuries do not involve dislocation of the proximal radioulnar joint [23].
- Monteggia fractures can be easily overlooked if radiographs of the elbow are not taken [52].
- Pre-existing congenital radial head dislocations can lead to inappropriate surgical intervention in Monteggia fractures [52].
- Radial neck fractures in young children with Monteggia fracture-dislocations may be missed on initial roentgenograms [53].
- There is a need for a high index of suspicion of a possible radial head fracture in Monteggia fracture dislocations [54].
- The clinical outcome of posterior Monteggia lesions remains unpredictable, particularly when there is an associated radial head fracture [56].
- The ulnar fracture pattern in anterior Monteggia fractures may be either a simple diaphyseal injury or a more complex metaphyseal injury [108].
- Complex metaphyseal ulnar injuries in anterior Monteggia fractures have a less favourable prognosis, in part because such injuries also involve an element of fracture dislocation at the elbow joint itself [108].
- It is unusual to sustain two Monteggia fractures of the same forearm [5].

GALEAZZI FRACTURE-DISLOCATIONS

- The Galeazzi fracture is a fracture of the middle to distal third of the radius associated with dislocation and/or instability of the distal radioulnar joint (DRUJ) [38].
- The Galeazzi fracture has been described as a fracture of necessity, which refers to the need of surgical treatment for optimal results [38].
- The Galeazzi fracture has been described as the Piedmont fracture [38].
- The Galeazzi fracture has been described as the reverse Monteggia fracture [38].
- Galeazzi fracture-dislocations often go unrecognized [38].
- An unstable Galeazzi lesion can be mistaken for a simple radius fracture [38].
- Dislocation of the distal radioulnar joint should be suspected at the time of injury with a displaced fracture of the distal shaft of the radius [38].

- Persistent instability of the distal radioulnar joint leads to an unfavorable result, with pain at the joint and restriction of forearm rotation [38].
- Ability to accurately diagnose true Galeazzi injuries preoperatively based on radiographs alone is limited [82].
- Radial shortening was greater, on average, in patients who had clinically significant DRUJ injury as compared to those with isolated radial shaft fractures alone [82].
- The difference in radial shortening between Galeazzi and isolated radial shaft fractures was not helpful in diagnosing the injury [82].
- Increasing the criterion for radial shortening to 10 mm was not accurate for diagnosis in individual cases [82].
- Three patients with DRUJ instability would have been missed and four patients would have been overdiagnosed using a 10 mm radial shortening criterion [82].
- Type II Galeazzi fractures (middle third, >7.5 cm from midarticular surface) were largely stable after radial shaft fixation alone [14].

ISOLATED ULNAR SHAFT FRACTURES

- Clinical studies continue to yield contradicting results regarding the optimal treatment of isolated ulnar shaft fractures [16].
- The healing characteristics of isolated ulnar shaft fractures do not appear to differ substantially between surgical and nonsurgical treatment [45].
- Nearly 20% of patients treated nonsurgically for isolated ulnar shaft fractures may require eventual open reduction and internal fixation (ORIF) [45].

COMPLEX AND ASSOCIATED INJURIES

- Fracture of the radial shaft may be isolated, but is more commonly associated with an ulnar fracture or with a distal radioulnar dislocation (Galeazzi fracture-dislocation) [35].
- Elbow dislocation with ipsilateral radial and ulnar shaft fractures is rare [90].
- Considerable force is required to produce the pattern of injury involving elbow dislocation with ipsilateral radial and ulnar shaft fractures [90].
- The clinician must have a high suspicion for associated complications in cases of elbow dislocation with ipsilateral forearm fractures [90].

Investigations

RADIOGRAPHIC ASSESSMENT

- Pre-existing congenital radial head dislocations can lead to inappropriate surgical intervention when evaluating Monteggia fractures [52].

- A high index of suspicion for a possible radial head fracture is required in Monteggia fracture dislocations [54].
- Films obtained within 4 weeks of surgery for radial shaft fractures are unlikely to change postoperative management and may not be warranted during routine postoperative follow-up [31].
- A radial shaft fracture obliquity greater than 30 degrees is predictive of distal radioulnar joint instability [106].
- Radial shaft fracture obliquity greater than 30 degrees was the most sensitive radiological parameter (76%) for predicting distal radioulnar joint instability [106].
- Contralateral lateral wrist radiographs are moderate to strongly reliable in determining a distal ulnar diaphyseal angle [135].
- Malunited diaphyseal fractures of both forearm bones showed complex deformities, suggesting that 3-dimensional modeling may be a more effective method than standard computed tomography or radiographs [101].

ADVANCED IMAGING (MRI AND ULTRASOUND)

- MRI and ultrasound imaging should both be considered when forearm interosseous membrane integrity is in question [116].
- Ultrasound effectively diagnosed and precisely located the torn interosseous membrane in forearm fractures/dislocations [133].
- In cases of torn interosseous membrane, the tear was found to be in the substance of the fibers closer to the ulnar shaft distally [133].

PHYSICAL EXAMINATION AND CLINICAL ASSESSMENT

Treatment

GENERAL PRINCIPLES AND OUTCOMES

- The goal of treatment for forearm diaphyseal fractures is to maintain length and radioulnar joint relationships to regain full pronosupination [91].
- Two years after surgical treatment of a Galeazzi fracture, there is a mean absolute loss of strength of supination of 16.1 kg (12.5%) and pronation of 19.1 kg (27.2%) [47].

OPERATIVE MANAGEMENT

- Treatment of diaphyseal forearm non-unions using classic techniques of compression plating osteosynthesis and autologous bone grafting if needed will lead to a high union rate (100% in the reported series) [112].

NON-OPERATIVE MANAGEMENT

- Isolated ulnar shaft fractures can be treated simply, cheaply and effectively by providing minimal support and early mobilization [107].
- An above elbow cast was unnecessarily restrictive for the treatment of isolated ulnar fractures in adults [64].
- Nonoperative treatment of displaced ulnar nightstick fractures produces a high risk of complications, and the fracture characteristics determine patient outcome [128].
- The healing characteristics of isolated ulnar shaft fractures do not appear to differ substantially between surgical and nonsurgical treatment, although nearly 20% of patients treated nonsurgically may require eventual ORIF [45].
- Nonoperative management of forearm fractures in adults typically leads to unacceptable outcomes, even in minimally displaced fractures, due to deforming forces that lead to shortening and angulation [91].

SPECIFIC INJURY PATTERNS AND COMPLICATIONS

- Dislocation of the distal radioulnar joint should be suspected at the time of injury with a displaced fracture of the distal shaft of the radius, as persistent instability leads to an unfavorable result with pain and restriction of forearm rotation [38].
- Forearm malunions may occur following either non-operative or operative treatment of acute fractures as well as following deformity correction surgery [89].

Complications

NEUROLOGICAL AND SOFT TISSUE

JOINT INSTABILITY AND FUNCTIONAL DEFICITS

BONE HEALING AND ATROPHY

- The long-term fixation of forearm diaphyseal fractures using a locking plate leads to progressive bone atrophy [30].
- Atypical forearm fractures are probably more common than reported in the literature to date, and all forearm lesions were accompanied by preceding atypical femur fractures [20].

SPECIFIC INJURY PATTERNS AND OUTCOMES

- An excellent clinical result was obtained in this unusual injury by adhering to the basic principles learnt from the management of Monteggia and other proximal forearm fractures [1].
- This case is presented because it is unusual to sustain two Monteggia fractures of the same forearm and the authors could find no such case in a review of the literature [5].
- We feel that in the osteoporotic patient, an isolated fracture of the ulnar shaft is perhaps most safely treated in a long arm cast [6].

- Type II fractures (middle third, >7.5 cm from midarticular surface) were largely stable after radial shaft fixation alone [14].
- The most common fractures in our study were simple, isolated radial shaft fractures, which are generally very rare injuries [34].
- During the twenty-year study period, the incidence of pediatric diaphyseal forearm fractures increased fivefold, with trampolining being the most usual single reason for the fractures [60].

Recovery

FUNCTIONAL OUTCOMES AND RANGE OF MOTION

- The clinical outcome of posterior Monteggia fractures remains unpredictable, particularly when there is an associated radial head fracture [56].
- Posterior Monteggia fractures present a complex management problem with a fine balance between the need to ensure fracture union and the preservation of elbow function and range of movement [61].

LONG-TERM COMPLICATIONS AND MONITORING

POSTOPERATIVE IMAGING AND FOLLOW-UP

TREATMENT EFFICACY AND UNION

- Clinical and functional outcomes of LCP plating of diaphyseal forearm fractures are comparable to the use of conventional implants [111].
- Timely surgical management with plating and radial head prosthesis of a rare Bado type IV Monteggia-equivalent fracture in adults results in a good prognosis [59].

Key Evidence

- [L5] An excellent clinical result was obtained in this unusual injury by adhering to the basic principles learnt from the management of Monteggia and other proximal forearm fractures. [1] ([10.1016/0020-1383\(95\)00077-m](#))
- [L3] Surgical intervention in neglected diaphyseal forearm fractures leads to a satisfactory outcome. [2] ([10.7759/cureus.31035](#))
- [L4] Isolated fractures of the radial diaphysis are more common than true Galeazzi fractures. [3] ([10.1016/j.jhsa.2005.09.003](#))
- [L4] Long term follow-up is absolutely necessary to monitor ulnar growth in Galeazzi-equivalent fractures. [4] ([10.1142/s0218810417720133](#))
- [L5] This case is presented because it is unusual to sustain two Monteggia fractures of the same forearm and the authors could find no such case in a review of the literature. [5] ([10.1016/0020-1383\(80\)90007-8](#))

- [L4] We feel that in the osteoporotic patient, an isolated fracture of the ulnar shaft is perhaps most safely treated in a long arm cast. [6] ([10.1007/bf00431043](#))
- [L4] Closed nailing can be treatment of choice in any forearm shaft fractures. [7] ([10.1016/s0020-1383\(11\)70027-4](#))
- [L4] Treatment of adult forearm diaphyseal fracture with the new intramedullary nails have promising results. [8] ([10.1016/s0020-1383\(13\)70138-4](#))
- [L4] In isolated ulnar shaft fractures, essentially no immobilization allows rapid healing with a lower rate of loss of forearm motion compared to literature reports. [9] ([10.2106/00004623-198365030-00007](#))
- [L5] Optimal outcomes in the treatment of forearm fracture–dislocations depend on early recognition and management, with restoration and maintenance of anatomic alignment being the key principles. [11] ([10.1016/j.hcl.2015.01.010](#))
- [L4] Type II fractures (middle third, >7.5 cm from midarticular surface) were largely stable after radial shaft fixation alone. [14] ([10.1053/jhsu.2001.21523](#))
- [L4] Both surgical and nonsurgical management of isolated ulnar shaft fractures are reported as acceptable forms of treatment with high union rates and good functional outcomes. [15] ([10.1016/j.hcl.2007.01.004](#))
- [Letter] Clinical studies continue to yield contradicting results, and retrospective studies are not able to solve the debate on the optimal treatment of isolated ulnar shaft fractures. [16] ([10.1016/j.injury.2015.07.010](#))
- [L4] The majority of isolated fractures of the ulnar shaft can be treated adequately by closed means, and the use of short casts is recommended. [18] ([10.1016/0020-1383\(81\)90004-8](#))
- [L3] Atypical forearm fractures are probably more common than reported in the literature to date, and all forearm lesions were accompanied by preceding atypical femur fractures. [20] ([10.1016/j.injury.2020.10.087](#))
- [L5] [23] ([10.1016/j.hcl.2007.01.008](#))
- [L4] Although most ulnar shaft fractures heal successfully with nonsurgical management, a substantial percentage of these fractures do not. [24] ([10.1016/j.jhsa.2023.09.009](#))
- [L4] The results of these two different fixation methods for treatment of fractures of the forearm in adults are similar. [25] ([10.1016/s0020-1383\(13\)70155-4](#))
- [L3] Intra-medullary pinning of the radius in Galeazzi fractures gives good results compared to plate osteosynthesis. [26] ([10.1016/j.main.2011.06.011](#))
- [L4] Treatment plans for forearm fracture should take into consideration the impact of bone atrophy long after plate fixation. [27] ([10.1016/j.jhsa.2017.03.041](#))
- [L5] This article reviews the evolution of operative and nonsurgical treatment techniques for forearm diaphyseal fractures from preanesthesia times until today, highlighting the transition from nonsurgical methods with high complication rates to plate osteosynthesis as the surgical treatment of choice after World War II. [28] ([10.1016/j.jhsa.2013.06.020](#))
- [L4] Results of surgical fixation have been good, with only modest losses of forearm strength and rotation. [29] ([10.5435/jaaos-22-07-437](#))

- [L4] The long-term fixation of forearm diaphyseal fractures using a locking plate leads to progressive bone atrophy. [30] ([10.1016/j.jhsg.2021.05.013](#))
- [L3] Films obtained within 4 weeks of surgery for radial shaft fractures are unlikely to change postoperative management and may not be warranted during routine postoperative follow-up. [31] ([10.1177/1558944715627629](#))
- [L4] When comparing the 1990s with the 1950s, there is still an increase in the incidence of forearm fractures in both genders. [32] ([10.3109/17453679909011249](#))
- [L4] Internal fixation by plating is a satisfactory method of treatment for adult forearm fractures, leading to excellent results in a majority of patients. [33] ([10.1016/0020-1383\(83\)90162-6](#))
- [L3] [34] ([10.1097/corr.0000000000001982](#))
- [L4] [35] ([10.1016/j.main.2013.07.004](#))
- [Paper] [38] ([10.1016/j.hcl.2007.03.004](#))
- [L4] The frequency of neurological complications concomitant to forearm fractures is noteworthy. [40] ([10.1016/j.otsr.2016.04.014](#))
- [L5] Utilizing a Delphi process, expert consensus was reached generating a comprehensive list of 26 assessment parameters that can be used to assess surgeon performance in open reduction and internal fixation of an isolated adult ulnar shaft fracture. [41] ([10.1016/j.injury.2025.112650](#))
- [L3] Children under the age of 15 suffered a total of 360 wrist and forearm fractures during the three winter months; an incidence of 5.9/1000 per year that was only about half that observed during the remainder of the year (10.7/1000 per year). [42] ([10.1016/s0020-1383\(02\)00212-7](#))
- [L4] Problems with the elbow related to fractures of the coronoid process and the radial head remain the most challenging elements in the treatment of these injuries. [43] ([10.2106/00004623-199812000-00003](#))
- [L4] The healing characteristics of isolated ulnar shaft fractures do not appear to differ substantially between surgical and nonsurgical treatment, although nearly 20% of patients treated nonsurgically may require eventual ORIF. [45] ([10.1016/j.jhsa.2022.02.009](#))
- [L3] Two years after surgical treatment of a Galeazzi fracture, there is a mean absolute loss of strength of supination of 16.1 kg (12.5%) and pronation of 19.1 kg (27.2%). [47] ([10.1302/0301-620x.95b11.31524](#))
- [L4] Individualized kinematic modeling of forearm malunions reliably detects clinically relevant limitations of forearm rotation without requiring dynamic imaging. [51] ([10.1097/corr.0000000000003945](#))
- [L4] Monteggia fractures can be easily overlooked if radiographs of the elbow are not taken, and pre-existing congenital radial head dislocations can lead to inappropriate surgical intervention. [52] ([10.1016/j.injury.2005.08.028](#))
- [L4] This case report illustrates the successful operative treatment of Monteggia fracture dislocation with associated radial head fracture with excellent results and reiterates the importance of holding a high index of suspicion of a possible radial head fracture in Monteggia fracture dislocations. [54] ([10.1016/j.injury.2005.05.017](#))

- [L4] The clinical outcome remains unpredictable, particularly when there is an associated radial head fracture. [56] ([10.1016/0020-1383\(95\)00187-5](#))
- [Case_report] Timely surgical management with plating and radial head prosthesis of this rare Bado type IV Monteggia-equivalent fracture in adults results in a good prognosis. [59] ([10.5397/cise.2021.00752](#))
- [L4] During the twenty-year study period, the incidence of pediatric diaphyseal forearm fractures increased fivefold, with trampolining being the most usual single reason for the fractures. [60] ([10.1186/s12891-023-06241-z](#))
- [L5] As they suggest in their paper, posterior Monteggia fractures remain a complex management problem with a fine balance between the need to ensure fracture union and the preservation of elbow function and range of movement. [61] ([10.1016/s0020-1383\(97\)87231-2](#))
- [L1] An above elbow cast was unnecessarily restrictive. [64] ([10.1016/s0020-1383\(00\)00051-6](#))
- [L5] Galeazzi injuries are unstable fracture dislocations requiring surgical management to achieve optimal outcomes. [65] ([10.1016/j.hcl.2020.07.006](#))
- [L3] [82] ([10.1016/j.injury.2016.04.003](#))
- [L4] [89] ([10.1007/s11552-014-9635-9](#))
- [L5] [90] ([10.1016/s0020-1383\(02\)00143-2](#))
- [L4] [91] ([10.1016/j.hcl.2010.04.002](#))
- [L4] Severe osseous, soft tissue, and neural trauma affect the functional results of the elbow region. [95] ([10.1186/1749-799x-1-12](#))
- [L4] [96] ([10.1055/s-0040-1712515](#))
- [L4] [98] ([10.1016/j.jhsa.2021.07.023](#))
- [Case_report] [99] ([10.1007/s00402-010-1253-6](#))
- [L4] Malunited diaphyseal fractures of both forearm bones showed complex deformities, which suggests that 3-dimensional modeling may be a more effective method than standard computed tomography or radiographs. [101] ([10.1016/j.jhsa.2013.03.052](#))
- [L4] The contribution of concavity-compression stability across the radiocapitellar joint to overall elbow stability is clearly demonstrated. [103] ([10.1177/1758573216673527](#))
- [L5] [105] ([10.1007/s00068-008-8028-6](#))
- [L3] A radial shaft fracture obliquity greater than 30 degrees is predictive of distal radioulnar joint instability ($P = 0.001$) and was the most sensitive radiological parameter (76%) for predicting this instability. [106] ([10.1177/1753193418756591](#))
- [L2] Isolated ulnar shaft fractures can be treated simply, cheaply and effectively by providing minimal support and early mobilization. [107] ([10.1016/0020-1383\(91\)90043-e](#))
- [L4] The ulnar fracture pattern may be either a simple diaphyseal injury or a more complex metaphyseal injury which has a less favourable prognosis, in part because such injuries also involve an element of fracture dislocation at the elbow joint itself. [108] ([10.1016/s0020-1383\(97\)88339-8](#))

- [L4] Clinical and functional outcomes of LCP plating of diaphyseal forearm fractures are comparable to the use of conventional implants. [111] ([10.1007/s00402-010-1119-y](#))
- [L4] Treatment of diaphyseal forearm non-unions using classic techniques of compression plating osteosynthesis and autologous bone grafting if needed will lead to a high union rate (100% in our series). [112] ([10.1007/s00402-010-1071-x](#))
- [L5] Increasing magnitudes of soft tissue disruption result in greater anterior radial head instability. [113] ([10.1016/j.jse.2019.10.025](#))
- [Paper] With the elbow in valgus alignment, an average of 93% of force applied to the wrist was transferred directly through the radius to the elbow with no appreciable load transfer through the interosseous membrane. [114] ([10.1053/jhsu.2000.8640](#))
- [Paper] We conclude that MRI and US imaging should both be considered when forearm interosseous membrane integrity is in question. [116] ([10.1053/jhsu.2002.32961](#))
- [L5] Biomechanical changes explain the pathological changes in the annular ligament during Monteggia fractures; longitudinal displacement of the radial head causes it to slip out of the annular ligament while the ligament remains intact. [118] ([10.1186/s13018-015-0170-3](#))
- [L4] Most major traumatic plastic bowing deformities of the ulna involved rotation rather than bending. [122] ([10.1016/j.jse.2011.12.006](#))
- [L5] Migration of the radius under loads implies disruption of both the central band and triangular fibrocartilage complex. [125] ([10.1016/j.jhsg.2023.06.003](#))
- [Case_report] The mechanism causing delayed radial head dislocation involved eccentric torque on the radial head during forearm pronation resulting from malunion of the radius. [126] ([10.1016/j.jse.2006.05.014](#))
- [L3] Nonoperative treatment of displaced fractures produces a high risk of complications, and the fracture characteristics determine patient outcome. [128] ([10.1016/j.injury.2015.02.012](#))
- [L4] The direction of radial head dislocation (anterolateral or posterolateral) may depend on the rotational position of the forearm at the time of the primary adduction injury. [132] ([10.2106/00004623-197759040-00024](#))
- [L4] Ultrasound effectively diagnosed and precisely located the torn IOM, which was found to be torn in the substance of the fibers closer to the ulnar shaft distally in all 3 cases. [133] ([10.1053/jhsu.1999.0257](#))
- [L4] Contralateral lateral wrist radiographs are moderate to strongly reliable in determining a DUDA. [135] ([10.1016/j.jhsa.2021.08.003](#))
- [L4] Anatomic reduction of the ulna is critical to achieving a favorable outcome, as it indirectly reduces the radiocapitellar joint. [136] ([10.5435/jaos-d-19-00625](#))
- [L4] Correction of the ulnar deformity with elongation and angulation of the ulna in the opposite direction of the dislocation of the radial head is the most important factor for the reduction and consequent preservation of the radial head. [137] ([10.1097/mop.0000000000000710](#))

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