Chapter 5
The Forearm

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Simple fractures of the radius and ulna can occur at any level between the elbow and the wrist. These fractures are very unstable and are best treated by internal fixation of the both bones (Figs. 5.1 and 5.2). Closed reduction of fractures of these bones may appear satisfactory, but they have a tendency to redisplace (Figs. 5.3 and 5.4).

Isolated single bone fractures of the radius or the ulna have a high chance of nonunion (Fig. 5.5) and are best treated by internal fixation.

Monteggia Fracture

Fractures between the proximal third of the ulna and the base of the olecranon combined with an anterior dislocation of the proximal radioulnar joint were described by Monteggia in 1814. Bado coined the term Monteggia fracture in 1967 and described four different patterns of the Monteggia lesion.

Historical Background

Giovanni Batista Monteggia, a surgical pathologist and public health official in Milan, first described Monteggia fractures. In his monograph, Bado defined the

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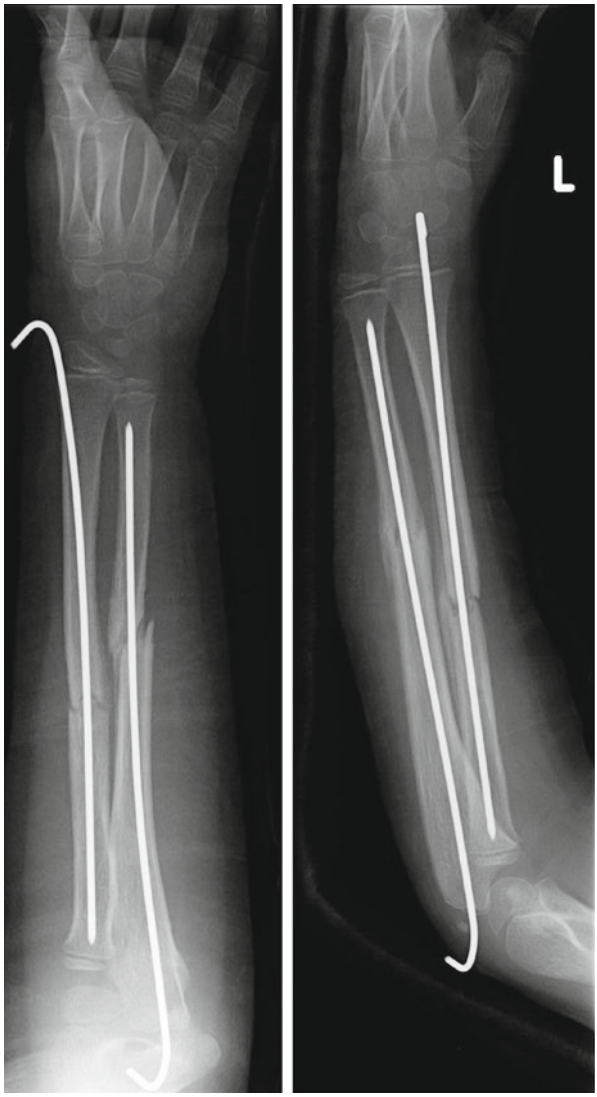

Fig. 5.1 Closed reduction and percutaneous pinning of the fractures of radius and ulna (Courtesy of Dilip Malhotra, Bahrain)

Monteggia lesion as an association of a radial head fracture or dislocation with a fracture of the middle or proximal ulna.

Classification

Bado's classification divides Monteggia fractures into four types of true Monteggia lesions and equivalent lesions

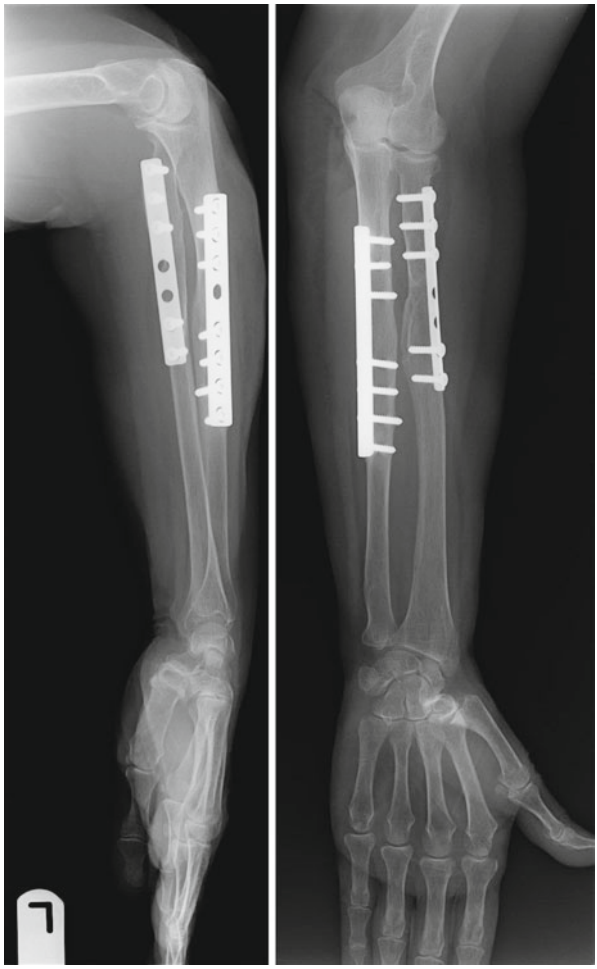

Fig. 5.2 Open reduction and internal fixation by plating of both bones of the forearm (Courtesy of Dilip Malhotra, Bahrain)

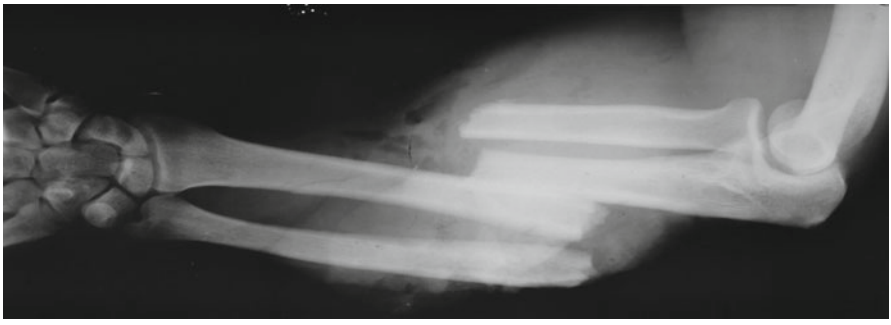

Fig. 5.3 Simple fracture of the mid-shaft of the radius and ulna (Courtesy of Magdi E. Griess, Whitehaven, Cumbria, UK)

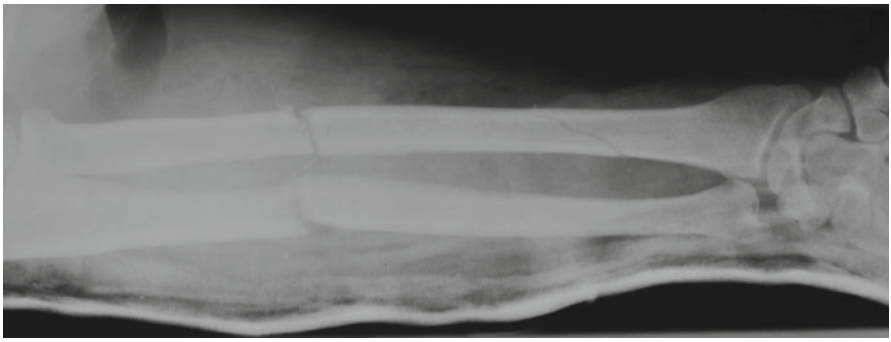

Fig. 5.4 Above fracture showing satisfactory reduction but with a tendency to redisplace (Courtesy of Magdi E, Greiss, Whitehaven, Cumbria, UK)

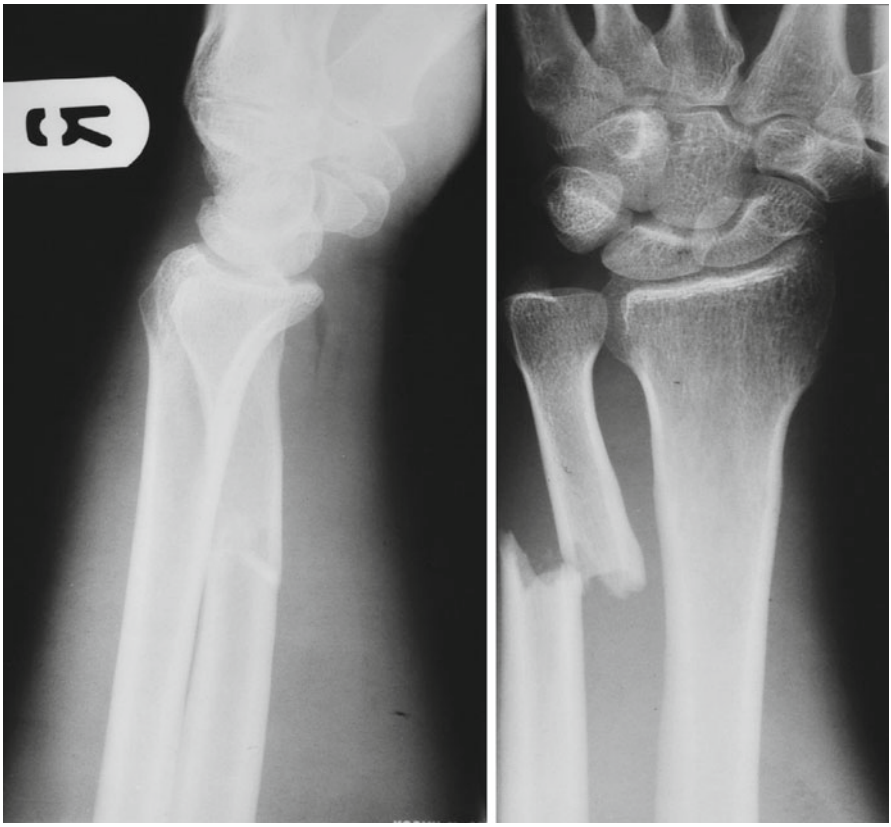

Fig. 5.5 Isolated fracture of the ulna with nonunion (Courtesy of Magdi E. Griess, Whitehaven, Cumbria, UK)

Bado's Classification

(a) Type I (anterior dislocation): the radial head is dislocated anteriorly and the ulna has a short oblique or greenstick fracture in the diaphyseal or proximal metaphyseal area.
(b) Type II (posterior dislocation): the radial head is posteriorly or posterolaterally dislocated; the ulna is usually fractured in the metaphysis in children.
(c) Type III (lateral dislocation): there is lateral dislocation of the radial head with a greenstick metaphyseal fracture of the ulna.
(d) Type IV (anterior dislocation with radius shaft fracture): the pattern of injury is the same as with a type I injury, with the inclusion of a radius shaft fracture below the level of the ulnar fracture.

Pediatric Monteggia Fracture Classification by Letts et al.

(a) Anterior dislocation of the radial head with plastic deformation of the ulna
(b) Anterior dislocation of the radial head with greenstick fracture of the ulna
(c) Complete fracture of the ulna with anterior dislocation of the radial head
(d) Posterior dislocation of the radial head with fracture of the ulnar metaphysis
(e) Lateral dislocation of the radial head and metaphyseal greenstick fracture of the ulna

Radiographic Evaluation

The standard evaluation of a Monteggia fracture includes anteroposterior (AP) and lateral x-rays of the forearm (Fig. 5.6).

Radiocapitellar Relation

Best defined by a true lateral view of the elbow: Line drawn through the center of the radial neck and head should extend directly through the center of the capitellum. This alignment should remain intact regardless of the degree of flexion or extension of the elbow

Composite drawing with the elbow in various degrees of flexion: A line drawn down the long axis of the radius bisects the capitellum of the humerus regardless of the degree of flexion or extension of the elbow.

Fig. 5.6 Monteggia fracture (Courtesy of Sharad Goyal, Chichester, West Sussex, UK)

Mechanism of Injury

Three separate mechanisms of type I lesions have been described: direct trauma, hyperpronation, and hyperextension.

Direct Blow Theory

The fracture dislocation is sustained by direct contact on the posterior aspect of the forearm, either by falling onto an object or by the object striking the forearm. The continued motion of the object forward dislocates the radial head after fracturing the ulna.

Hyperpronation Theory (Evans)

Rotation of the body externally forces the forearm into pronation. The ulnar shaft fractures with further rotation, forcibly dislocating the radial head.

Hyperextension Theory

(a) Hyperextension: forward momentum caused by a fall on an outstretched hand forces the elbow into extension.
(b) Radial head dislocation: the biceps contracts, forcibly dislocating the radial head.
(c) Ulnar fracture: forward momentum causes the ulna to fracture because of tension on the anterior surface.

Mechanism of Injury Type II

The mechanism proposed and experimentally demonstrated by Penrose was that type II lesions occur when the forearm is suddenly loaded in a longitudinal direction with the elbow flexed 60°.

Mechanism of Injury Type III

A forced varus stress causes a greenstick fracture of the proximal ulna and a true lateral or anterolateral radial head dislocation.

Mechanism of Injury Type IV

Bado proposed that a type IV lesion is caused by hyperpronation

Clinical Findings

- Marked pain and tenderness about the elbow. No flexion, extension, pronation, and supination. Paralysis of the interosseous nerve may occur.
  Type 1: head of radius felt anteriorly, anterior angulation
  Type 2: head of radius posterior, posterior angulation of ulna shortening of forearm
  Type 3: head of radius is lateral, lateral angulation
  Type 4: head of radius is anterior; deformity is at the fracture level

Treatment: In Children

Type 1: Closed reduction (if fails), open reduction of fracture ulna + closed reduction of head of radius.

If not reducible by closed methods, then one needs to go for open reduction of fracture ulna with open reduction of head of the radius.
Type 2: Closed reduction: if it fails, open reduction.
Type 3: Closed reduction.
Type 4: Closed reduction: if it fails, open reduction with plate and screw.

Treatment: In Adults

- Open reduction internal fixation of fracture ulna with plate and screws
- Closed reduction of head of radius if fails
- Open reduction head of radius + internal fixation of ulna
- If fracture more than 6 weeks excision head of radius is done.

Immobilization after reduction can be done in plaster cast for 3–6 weeks.

Complications

- Posterior interosseous nerve palsy
- Radial head instability
- Nonunion of fracture ulna
- Malunion of fracture ulna
- Myositis ossificans
- Missed Monteggia lesions/possible long-term sequelae

Progressive valgus

Proximal radial migration with disruption of normal forearm and distal radioulnar joint

Galeazzi Fractures

Fracture of distal one third radial shaft with dislocation of distal radioulnar joint is called Galeazzi fracture. Variants of Galeazzi fracture can occur anywhere along the

radius or associated with fractures of both bones with DRUJ disruption. Is also called "the fracture of necessity" by Campbell.

Galeazzi fracture dislocations are relatively rare injuries in children.

Mechanism of Injury

The mechanism of injury is axial loading in combination with extremes of forearm rotation. In adults, the mechanism of injury usually is an axially loading fall with hyperpronation.

Clinical Features

Pain, swelling, and deformity of the lower end of the forearm. Pronation and supination are severely restricted. Neurovascular injury is rare.

Radiography

Standard full-length forearm with elbow and wrist AP and lateral to be taken.

Classification

Walsh and McLaren classified pediatric Galeazzi injuries by the direction of displacement of the distal radial fracture. Dorsal displacement (apex volar) fracture was more common than volar displacement (apex dorsal) fractures in their series.

Treatment

Galeazzi fractures are also called "the fracture of necessity." Closed reduction has no role in treatment. Always requires open reduction, internal fixation with plate and screws. Sometimes require temporary pin fixation of DRUJ or repair of the ulnar styloid when fractured.

Postop if DRUJ stable start early motion. If DRUJ unstable, immobilize forearm in supination for 4–6 weeks in a long arm splint or cast. DRUJ pins are removed at 6–8 weeks.

Complications

1. Malunion leads to loss of supination and pronation.
   Treatment if it is persistent may require corrective osteotomy.
2. Nonunion. Treatment is bone grafting.
3. Compartment syndrome is rare

Galeazzi Equivalent

Radial shaft fracture with distal ulnar physeal injury instead of DRUJ injury. Distal ulnar physeal injuries have a high incidence for growth arrest.