2. Olecranon

The subcutaneous position renders the olecranon quite vulnerable to direct trauma. Hyperextension and torsion fractures of the olecranon are among the most common of elbow injuries.

2.1 Assessment of fractures and soft tissues

The fracture usually represents a disruption of the extensor (triceps) mechanism, with a bending moment over the distal end of the humerus, inducing the characteristic transverse and oblique B1 patterns. More direct forces generate fragmentation and impaction of the central portion of the articular surface of the olecranon, and occasionally avulsions of the coronoid process.

The patient is usually in pain and not able to use the elbow. The skin may be swollen, contused, or bruised. The lateral view clearly shows the fracture line, the amount of displacement, and the degree of fragmentation. A lateral computed tomogram may be useful to clarify the degree of articular impaction.

- The relationship between the radial head and capitellum must be carefully evaluated to look for displacement and instability.

Complex fractures can be associated with an anterior dislocation of the forearm (transolecranon fracture dislocation or subluxation), or a posterior type II Monteggia lesion [4].

Several classification systems have been described (Fig 6.3.1-2), but they do not describe the stability of the elbow joint.

- Simple transverse or oblique fractures are not necessarily stable, as they can be associated with elbow or forearm dislocations.

Fractures are associated with an unstable elbow joint if they involve the coronoid process or proximal ulna, but the elbow is likely to be stable if the fracture is confined to the trochlea notch, even if it is multifragmentary.

2.2 Treatment options

The vast majority of olecranon fractures require open reduction and internal fixation. However, nondisplaced fractures, with an intact extensor mechanism, can be treated nonoperatively. The key is to examine for active elbow extension with gravity eliminated. The aim of open reduction of a displaced fracture is to achieve anatomical reduction of the joint surface and stable fixation that allows early motion. Because of the eccentric pull of the triceps tendon, fractures are fixed using the tension band principle (chapter 3.2.3). For simple (transverse or oblique) fractures proximal to the coronoid process, a
6.3.1 Olecranon, radial head, and complex elbow injuries

figure-of-eight tension band wire may be used. For complex and more distal fractures, a tension band plate is applied. Separate articular fragments may require lag screw fixation with either technique.

2.3 Preoperative planning

2.3.1 Positioning and approaches

The patient should be either prone or in the lateral position with the elbow flexed over a side rest (Fig 6.3.1-3a). The supine position with the forearm placed across the chest is also acceptable (Fig 6.3.1-3b), especially if extended approaches to the lateral column are planned. A sterile tourniquet is placed on the upper arm after skin preparation and draping, but is only inflated in case of severe bleeding.

The skin incision runs posteriorly from the supracondylar area to a point 4 or 5 cm distal to the fracture. It can be gently curved to the radial side to protect the ulnar nerve or to avoid skin bruises or lacerations. Large skin flaps may not heal well and should be avoided. To expose the joint the insertion of the anconeus muscle is detached close to the ulna, as separating the fibers may denervate this muscle.

2.3.2 Reduction techniques and tools

A direct reduction technique, using hooks, pointed reduction forceps, or K-wires, is the method of choice for articular fractures (Fig 6.3.1-4).

Fig 6.3.1-3a–b Alternative positions for fixation of olecranon fractures.

a Lateral position. The fracture is easily approached from the posterior aspect.
b Supine position. The elbow is placed on an armrest above the patient’s chest and remains mobile.

An experienced assistant is often needed.
**6 Specific fractures**

**6.3 Forearm and hand**

**Fig 6.3.1-4a–d**

a Simple olecranon fractures are best reduced and held in place with a hook, followed by two 1.6 mm K-wires, which are introduced parallel to each other and which should penetrate the distal cortex. Alternatively, the K-wires can be inserted by the inside-out technique, which guarantees their optimal position in relation to the articular surface.

b A 1.0 mm stainless steel wire is passed through a 2.0 mm hole in the ulna and in a figure-of-eight underneath to the insertion of the triceps brachii muscle at the olecranon.

c The final aspect with the tension band wire in place. Note that the K-wires must be buried deep to the triceps tendon to prevent backing-out when the elbow is extended.

d In case of an oblique fracture that tends to shear off when the wire is tightened, a 4.0 mm lag screw may be used with or in place of the K-wires.
2.3.3 Choice of implants and tension band principle

Two K-wires (1.8 or 1.6 mm) as internal splints and one or two 1.0 mm stainless steel cerclage wires are the implants of choice for simple transverse and oblique fractures (Video 6.3.1-1). An additional lag screw should be used in selected oblique fractures to obtain uniform compression (Fig 6.3.1-4d). A longitudinal cancellous bone screw is an alternative but must be supplemented by a tension band wire loop. A posterior plate (one-third tubular plate, reconstruction plate, or LCP 3.5) is preferred for comminuted fractures (Fig 6.3.1-5) and those which extend distal to the coronoid process. A precontoured anatomical olecranon LCP 3.5 may be used.

2.4 Surgical treatment—tricks and hints

Transverse and oblique fractures

Flexing the elbow and detaching some fibers of the anconeus muscle from the lateral aspect exposes the fracture and articular surface. After irrigation and cleaning of the joint, the fracture is reduced, and any impacted articular fragment must be elevated into an anatomical position.

Direct reduction is achieved by extending the elbow and simultaneously reducing the fragments with a pointed forceps; its distal point can be anchored in the diaphysis in a small drill hole. The fixation method of choice is the tension band wire with two additional K-wires to hold the initial reduction and protect against rotational forces.

For oblique fractures, prior to the tension band fixation, an additional lag screw may be inserted at a right angle to the fracture plane to prevent any sliding. For more distal fractures, or those associated with soft-tissue instability, a posterior plate is the preferred choice. The plate will function as a tension band.

Multifragmentary fractures

In cases where a simple depressed fragment can be directly reduced and fixed with one or two K-wires, a regular tension band wire is applied as described. For more complex and comminuted fractures, indirect reduction is preferred. Definitive fixation is obtained by using a LCP 3.5 or reconstruction plate contoured to the proximal ulna. The most proximal screws are directed to the medullary canal and placed at a 90° angle to the other screws, thereby creating an interlocking construction [15–17].

An alternative is the custom-made one-third tubular hook plate. At one end of the plate the screw hole is cut and bent to form a bifid hook, which engages in the proximal fragment where it can be additionally fixed with screws (Fig 6.3.1-6). If a distractor is not available, the plate is used as a lever to facilitate reduction to the diaphysis. Because the plate is thin and can fail under load, this fixation should be augmented with a tension band wire or a further one-third tubular plate on top [18]. A hook plate can also be fashioned from a reconstruction plate 3.5, but this is technically demanding.
In more complex olecranon fractures, the tension band principle with cerclage wire may not work. Therefore, a small plate (one-third tubular plate, LCP 3.5, or reconstruction plate) is used in the manner of a tension band.

These plates require considerable contouring to bend around the tip of the olecranon. The plate is first anchored to the olecranon with two screws and, if needed, the Verbrugge forceps is added distally to compress the fracture.

Fixation with an additional lag screw through a reconstruction plate 3.5.

If the fracture is very proximal the LCP with locking head screws can be used to give better fixation.

New preshaped olecranon LCP.
6.3.1 Olecranon, radial head, and complex elbow injuries

2.5 Postoperative treatment

During the first 24–48 hours, a posterior splint may promote comfort, but is not essential. Active-assisted exercises are started within days, including gravity-assisted elbow flexion with the patient lying supine. During the first weeks an active exercise program should be closely monitored in order to avoid elbow contractures.

2.6 Pitfalls and complications

After the fracture has healed, prominent or protruding K-wires are not uncommon and may cause pain and require removal, which is otherwise optional. Nonunions are rare and usually unite after repair with the methods already described [16, 19–21].

2.7 Results

Most olecranon fractures heal primarily. The majority of patients regain a functional range of motion, frequently with some loss of extension, but only little disability.

3 Radial head

3.1 Assessment of fractures and soft tissues

Fractures of the radial head are caused by a fall on the outstretched hand, with the forearm slightly flexed and pronated. Fracture patterns range from simple and nondisplaced to multifragmentary and severely impacted. Elbow dislocation and associated soft-tissue injuries are not uncommon, as are fractures of the distal radius.

The patient is usually in pain and cannot rotate the forearm. As extension is also difficult and painful, an AP view is taken perpendicular to the forearm (Fig 6.3.1-7) with additional lateral and oblique radiocapitellar views. However, simple x-rays are often difficult to interpret, and an accurate assessment of the fracture configuration and associated injuries may only be possible at the time of surgery. Additional imaging techniques (CT scan, MRI) are seldom indicated.

Fig 6.3.1-6 As an alternative to Fig 6.3.1-5, a one-third tubular plate may be shaped or cut to form two sharp hooks that engage into the tip of the olecranon for better purchase in case of quite small fragments. This fixation should be augmented with a tension band wire or a further one-third tubular plate on top. The plate should be underneath the triceps brachii tendon and the tip must not impinge on the olecranon fossa.