

# Surgical Techniques of Olecranon Fractures

James A. Wilkerson, MD, Melvin P. Rosenwasser, MD

Olecranon fractures are common upper extremity injuries. The vast majority are treated with operative fixation. Many treatment techniques have been described including tension band and plating. This review covers the most commonly used fixation techniques in detail, including pearls and pitfalls with case examples of both successful treatments and potential complications. (*J Hand Surg Am.* 2014;39(8):1606–1614. Copyright © 2014 by the American Society for Surgery of the Hand. All rights reserved.)

**Key words** Elbow, fractures, olecranon, techniques, tension band.

**F**RACTURES OF THE OLECRANON process of the ulna are among the more common upper extremity fractures requiring operative intervention. Disabilities associated with untreated olecranon fractures result from disruption of the extensor mechanism. The associated functional limitations, including an inability to reach over the head or to push off, are substantial. The surgical indication is marked displacement with rare exception for severe medical comorbidities. Although this common injury is frequently operated on, it has complications. This review of olecranon fractures, treatments, and possible complications may provide guidance in improving patient outcomes.

## ANATOMY AND BIOMECHANICS

The elbow, specifically the humeroulnar joint, has anatomic features that must be navigated during the approach and internal fixation (Fig. 1). The sigmoid notch of the ulna, including the coronoid process,

provides the primary bony restraint of the elbow joint. It has a semilunar surface that articulates with the trochlea of the distal humerus. In the center of the notch in the axial plane is an area devoid of cartilage commonly referred to as the “bare spot.” This is the preferred location for osteotomies and minimizes articular cartilage injury. This is also the area where fractures most commonly occur, although many will have medial fragmentation of the proximal ulna as well. Other articulations, the radioulnar and radiohumeral joints, are not injured with isolated olecranon fractures but are often involved with more complex fracture-dislocations such as Monteggia fracture-dislocations.

Although many surgeons think of the ulna as a straight bone, the proximal shaft actually has a 10° apex lateral bow that must be appreciated when inserting intramedullary hardware. The coronoid process, which supports the distal portion of the sigmoid notch, is also the insertion of the anterior bundle of the medial collateral ligament. The medial collateral ligament stretches from the medial epicondyle to the sublime tubercle. This ligament is essential for elbow stability and must be protected during surgery.

There are 3 commonly described mechanisms of olecranon fractures: (1) a direct blow to the elbow, (2) acute tension overload from a sudden pull of the triceps tendon, and (3) chronic overload injuries as may be seen with repeated stress loading in osteopenic patients or through the apophysis in skeletally immature patients and occasionally in high-demand professional-level athletes.

Regardless of the mechanism of injury, the triceps muscle is the major deforming force on the fragments

From the Department of Orthopaedic Surgery, Columbia College of Physicians and Surgeons, and Columbia Department of Orthopaedic Surgery, New York Orthopaedic Hospital, New York, NY.

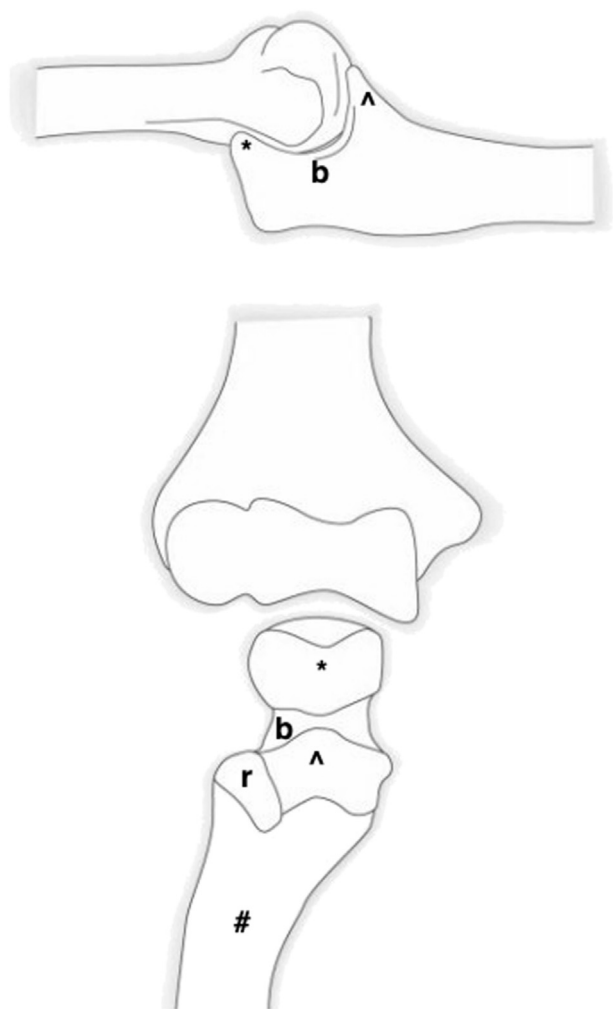
Received for publication February 21, 2014; accepted in revised form May 19, 2014.

The authors acknowledge Dr. W. Andrew Eglseder and Dr. Raymond Pensy of the University of Maryland and Shock Trauma Center, Department of Orthopaedics, for previous instruction and consultation on the fine points of the intramedullary screw technique.

No benefits in any form have been received or will be received related directly or indirectly to the subject of this article.

**Corresponding author:** Melvin P. Rosenwasser, MD, Columbia Department of Orthopaedic Surgery, New York Orthopaedic Hospital, 622 W. 168th Street, PH1119, New York, NY 10032; e-mail: [mpr2@columbia.edu](mailto:mpr2@columbia.edu).

0363-5023/14/3908-0030\$36.00/0  
<http://dx.doi.org/10.1016/j.jhsa.2014.05.014>



**FIGURE 1:** Relevant anatomy of the olecranon. The semilunar sigmoid notch features proximal (asterisk) and distal (circumflex) articular surfaces with the bare spot (b) in between. The radius articulates with the ulna at the proximal radioulnar joint (r). The proximal ulna features a 10° apex radial bow (number sign). (Reprinted with permission from Ring D, Jupiter JB. *Fractures of the proximal ulna*. In: Wolfe SWW, Pederson WC, Hotchkiss RN, Kozin SH. *Green's Operative Hand Surgery*. 2010; 821–836. Copyright © Elsevier 2010.)

after fracture. The triceps tendon inserts on the proximal ulna and as it contracts the proximal fragment it is retracted, leaving a large gap and obviating closed treatment.

There are several classifications for olecranon fractures. The Mayo classification, devised by Morrey,<sup>1</sup> is simple, has little interobserver variability, and can guide fracture management. Type I injuries are nondisplaced and make up 12% of fractures. Type II are displaced but the elbow is stable (82%), and in type III injuries the elbow is unstable. Types II and III are further classified as either A for noncomminuted or B for comminuted.

## INDICATIONS AND CONTRAINDICATIONS

Disruptions of the extensor mechanism, articular incongruity, and compromised soft tissue or tissue at risk all require operative intervention. The surgeon's goal is to restore articular congruence, repair the extensor mechanism, and minimize stiffness, pain, and the need for secondary interventions.

Compromise of the fragile skin over the proximal ulna may delay surgery or require modification of the surgical incision (Fig. 2). Occasionally there may be a grade I outside-in skin laceration that requires immediate attention. Palpate for bony displacement and fracture gap and assess triceps continuity and fracture stability by gentle active extension versus gravity. The ulnar nerve motor and sensory function should be documented as well as the presence of ulnar nerve subluxation at the cubital tunnel.

Radiographs with anteroposterior, lateral, and oblique views are usually sufficient to characterize the injury. Occasionally computed tomography scans may be helpful in assessing occult injury to adjacent ligament insertions and the chondral surfaces.

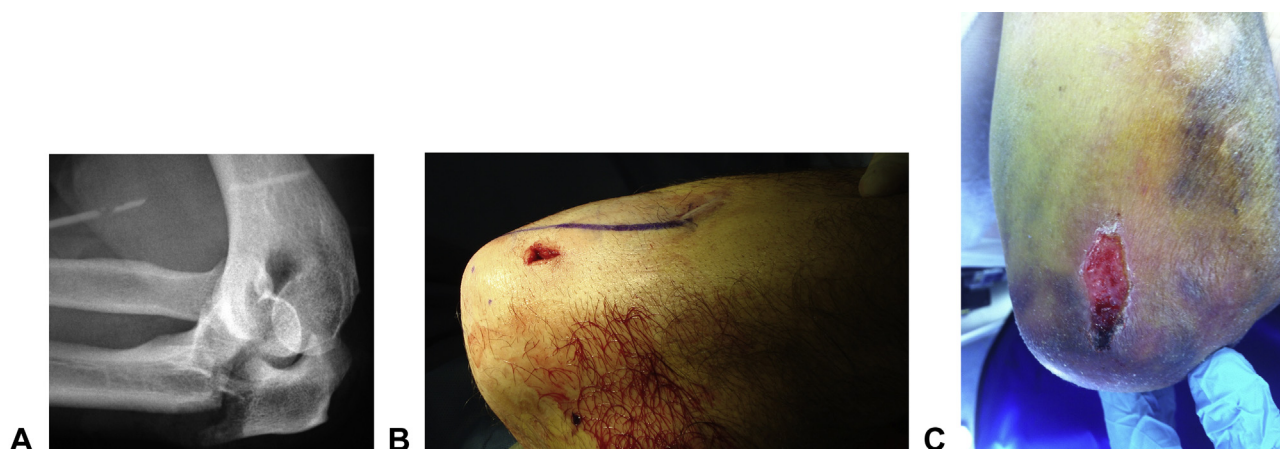
Higher kinetic energy and/or poor bone quality may cause more fragmentation affecting implant selection. Simple transverse patterns are managed with tension banding, whereas complex fractures with butterfly fragments may be better managed with plating in simple configurations or with multiple plates to provide more stability.

Special attention should also be paid to subtle cortical densities that may represent displaced portions of the articular surface. The olecranon and the trochlea are a congruent match. One should never discard small intermediate fragments. If the fracture is fixed without these pieces the articular arc will be narrowed, resulting in loss of mobility because of incongruence. If pieces are missing or are unusable, the articular surface should be realigned and bone graft or bone filler should be placed to support the reduction (Fig. 3).

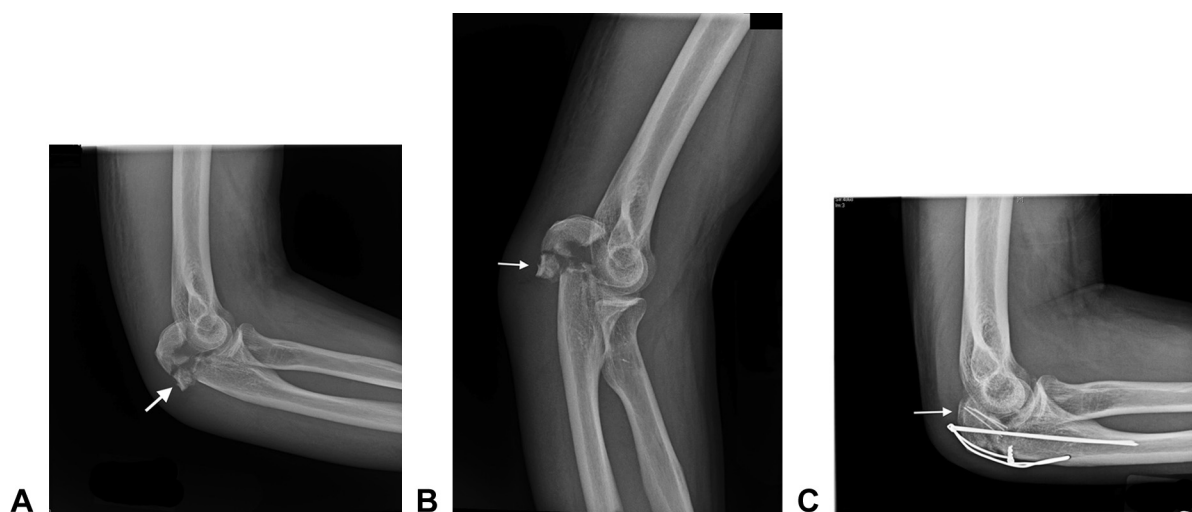
## TREATMENT AND SURGICAL TECHNIQUE

Patients who sustain nondisplaced to minimally displaced stable fractures with competent extensor mechanisms can be managed by splinting for 7 to 10 days followed by functional bracing for an additional 4 to 6 weeks. Surveillance should be bimonthly until union to avoid late displacement resulting from triceps pulling force, which is the most common complication.

Recent reports suggest that low-demand elderly patients with multiple comorbidities and increased surgical risk may be treated with splints, with good



**FIGURE 2:** Soft tissue compromise surrounding olecranon fractures. **A, B** Grade 1 open lesion from a dorsal cortex spike that required a modified approach to avoid the damaged skin. **C** Pressure wound from a splint that required delaying surgery until it had healed.



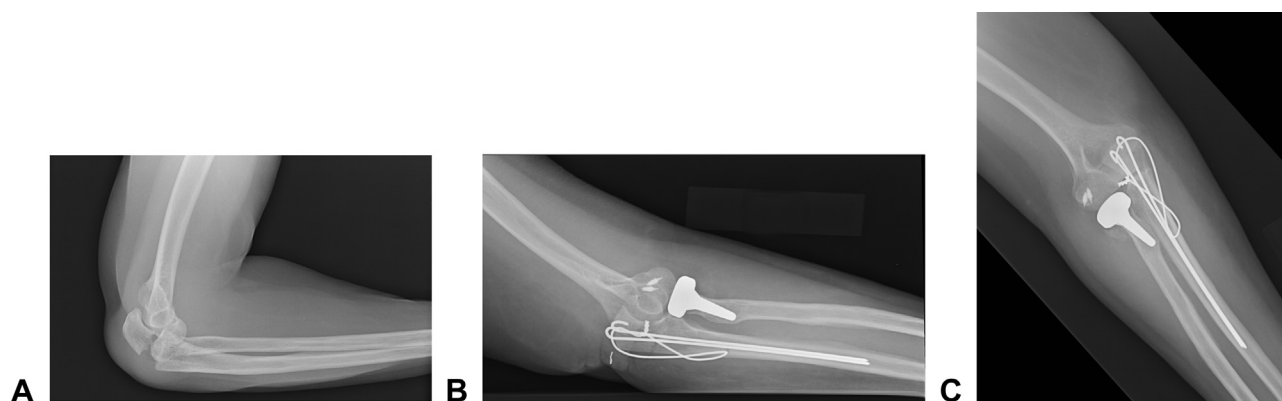
**FIGURE 3:** Comminuted intra-articular olecranon fracture. Note the curved chondral fragment (arrow) in **A** and **B**. The articular surface has been rotated 180° away from the joint. The fragment was reduced and fixed in place with fully threaded 0.035-in (0.9-mm) K-wires from inside the fracture, as seen in **C**. The K-wires are cut flush with the bone and left in place (arrow). We used 0.062-in K-wires with prefabricated eyelets with the tension band for this patient.

outcomes. Duckworth et al<sup>2</sup> reported on nonsurgical management of displaced fractures at a mean of 6 years in this population, including 87% with no pain and only 17% noting weakness.

Low-demand or osteopenic/osteoporotic patients with failed primary osteosynthesis can be salvaged with triceps advancement. Good results can be obtained as long as greater than 50% of the joint surface remains to provide a bony buttress to the tendon.<sup>3</sup>

There are 2 mainstays of operative treatment: tension banding with either intramedullary K-wires or an intramedullary screw versus plate fixation. Other options such as a locking intramedullary device have little clinical follow-up and have not been widely adopted.

Tension band constructs are the reference standard for simple transverse fractures. We prefer to use 2 long 0.062-in (1.6-mm) K-wires placed down the center of the canal with the tension band. After a preliminary reduction has been obtained and held by a large pointed reduction clamp, 2 vertical splits are made in line with the triceps tendon fibers to allow for passage of the K-wires down to the bone. This will later facilitate burying the wire to reduce hardware prominence. Only the near cortex is drilled and then the wires are advanced down the shaft with a mallet. This method allows the wires to conform and bend to the intramedullary canal of the ulna, much like an elastic femoral or tibial nail. The wires create an interference



**FIGURE 4:** **A** A 64-year-old woman sustained a complex fracture dislocation of the elbow in a fall. **B, C** The radial head was replaced and lateral collateral ligaments were repaired. The olecranon was fixed with long 0.062-in K-wires down the shaft of the ulna and tension band. The proximal K-wires were bent into hooks with the bent limb parallel to the shaft and impacted into the cortex after first capturing the tension band wire.

fit as they navigate the ulnar canal and do not become impaled in the far cortex, as frequently occurs when wires are drilled all the way in. Furthermore, they are less likely to back out, another frequent complication. This security is aided by predrilling the cortex to allow the hooked end of the wire to be fully impaled into the proximal ulna. To facilitate this, the hook is bent so that the second limb is exactly parallel to the main shaft of the wire. The full 9-in length of the K-wires is deployed to maximize the interference fit (Fig. 4).

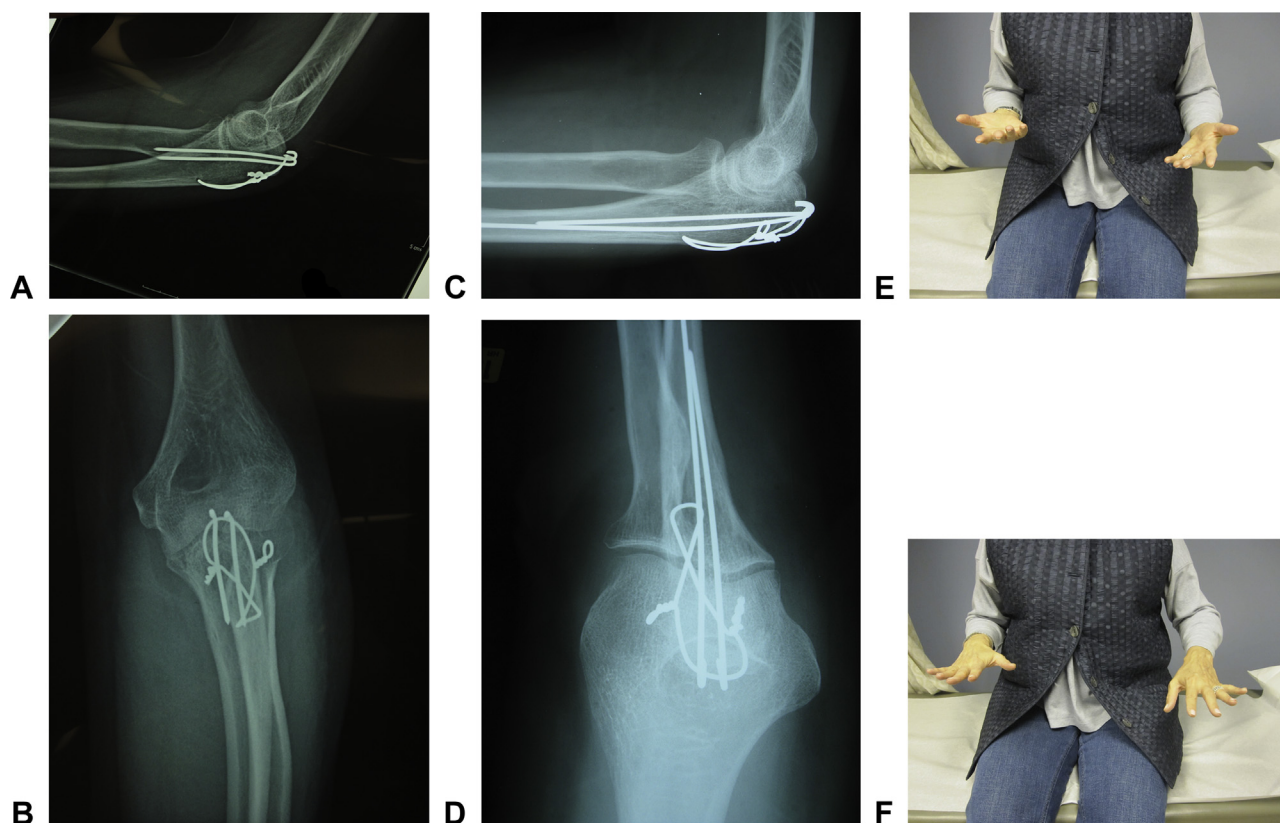
Another strategy to minimize K-wires backing out is to direct them anteriorly for anchorage in the cortex of the coronoid. This technique requires careful attention to a live fluoroscopic panorama once the wires are hooked and fully seated to ensure that the wires do not protrude and block forearm rotation, which has been reported<sup>4</sup> (Fig. 5). The length of the K-wires when engaging the cortex must be exact or it will be impossible to clamp the hooked ends into the proximal ulna and keep them buried beneath the triceps.

Before final impaction of the hooked wires the tension band is added. An 18-gauge wire is passed through a hole drilled in the ulna at least 2 fracture lengths distal to the primary fracture line. The hole is drilled medial to lateral through the canal just anterior to the dorsal cortex. The wire is passed through the hole and arranged in a figure-of-8 pattern over the olecranon. Proximally, the wire is passed under the triceps tendon and anterior to the proximal end of the hooked wires. It is important to have the wire against the bone with no intervening soft tissue. Both limbs of the figure-of-8 are tensioned equally with a double twist. Care must be taken to ensure that the wires form a true spiral when twisted rather than 1 wire

spiraling around a straight wire. Once the slack is out of the wire it usually takes 3 to 4 twists to obtain the proper tension. The bone reduction clamp holds the fracture compressed while the wires are tensioned. The reduction is assessed throughout tensioning to prevent displacement. Avoid kinking the wire when passing the figure-of-8 and do not crimp the wire, which may accelerate fatigue and failure. Once properly tensioned, the wires are cut at the twisted knot. Three full twists of the spiral are sufficient and necessary to preserve tension. The knots are then directed away from the subcutaneous border of the ulna with a final twist and seated with a tamp. The aponeurosis is then closed over the wire if possible.

After the tension band is applied the proximal ends of the K-wires are cut to the desired length and bent into hooks with parallel limbs as previously described. The hooks should be kept just wide enough to accommodate the tension band. They are then rotated to capture the tension band wire and seated. In patients with good bone it may be necessary to predrill the cortex for the hooks. The vertical splits in the triceps are closed over the wires to help reduce prominence and prevent backing out (Fig. 4).

Some surgeons prefer to use an intramedullary screw with a tension band rather than K-wires. If this option is to be used, it is important to use a long large-diameter screw. A 6.5-mm partially threaded screw with a washer is usually sufficient to achieve purchase in the endosteal cortex of the ulna. Once a provisional reduction has been obtained, the starting point for the screw is identified in the center of the olecranon in the anteroposterior plane to ensure that the head of the screw and washer will not impinge on the triceps and olecranon fossa. In the sagittal plane



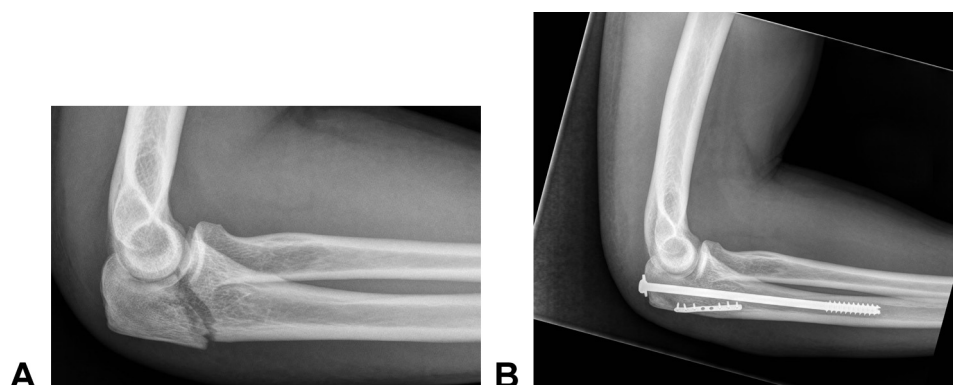
**FIGURE 5:** A 55-year-old woman fell and sustained an olecranon fracture that was fixed with a tension band and K-wires directed into the anterior cortex. She had marked pain and limitations with pronation and supination. An audible click was heard with pronation and supination. **A, B** The K-wires were noted to be prominent anteriorly impinging on the radius and the interosseous space. **C–F** She underwent revision using long intramedullary K-wires with restoration of pronation and supination.

the start point is lateral to the midline of the olecranon to account for the bow. This critical step allows an intramedullary screw to be passed down the canal without displacing the reduction. If the starting point is too medial, engagement of the screw in the cortex of the bow of the ulna will cause the screw to translate the proximal fragment. After identifying the starting point, the full length of a 3.2-mm drill bit sounds the canal, followed by a 4.5-mm bit. There should be only slight resistance if the drills are within the canal. If resistance is encountered, redirection of the drill is mandatory. The canal is tapped and the screw is passed until endosteal purchase is achieved. The screw length is measured off the tap and 10 mm is subtracted to allow for full seating and compression to occur. The tension band is then passed under the triceps tendon and deep to the washer before the screw has been completely seated. It is important to stabilize the fracture to counteract the torque as the screw is seated. This is done with 2 reduction clamps: 1 holding the proximal fragment and a second holding the distal piece. Alternate turning the screw and tensioning the wire to ensure an even distribution of

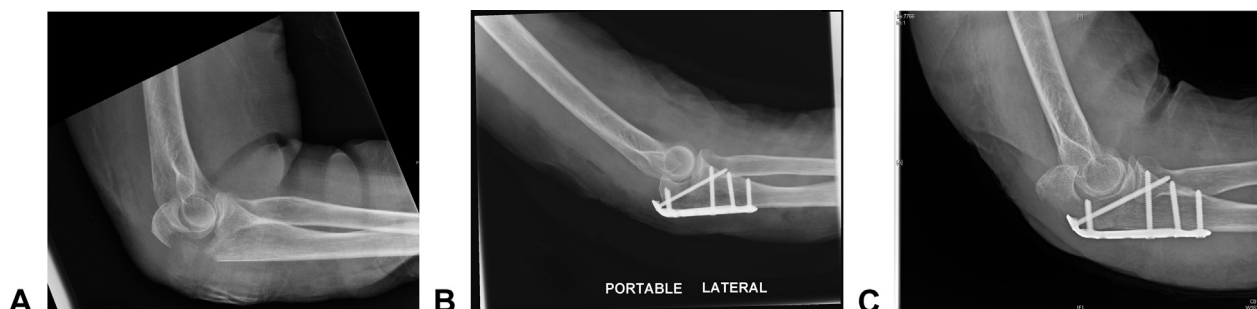
forces across the fracture. When seated, the screw and washer should be buried under a vertical split in the triceps tendon, which is closed over the screw to reduce prominence<sup>5</sup> (Fig. 6).

Comminuted or oblique fracture patterns are often unstable and may require fixation with standard or precontoured anatomic plates. Despite the lower profile of the newer designs, painful hardware is still common. The fracture pattern and bone quality may dictate the appropriate implant. In many cases the proximal fragment is small and many locking plates have insufficient proximal screws to capture this fragment. Loss of fixation with hardware still in place is a difficult situation for both the patient and the surgeon and may require a salvage procedure (Fig. 7). Sometimes both a tension band and a plate are required to maintain a stable reduction (Fig. 8).

Addition of medial or lateral plates to standard posterior plating can improve the stability of fragments outside the major plane secured by standard plates (Fig. 9). Regardless of technique or type and number or location of plates, the anatomic reduction of the joint surface remains paramount.



**FIGURE 6:** **A** Preoperative and **B** postoperative lateral radiograph of a 33-year-old man who sustained a closed olecranon fracture in a motorcycle accident. Provisional fixation was obtained with a unicortical mini fragment plate and then a partially threaded 7.3-mm intramedullary screw with a washer was used for definitive fixation. (Photo courtesy of Raymond Pensy, MD, University of Maryland R. Adams Cowley Shock Trauma Center, Baltimore, MD.)



**FIGURE 7:** **A** A 91-year-old woman who injured her olecranon in a fall underwent open reduction internal fixation with an olecranon plate that did not have enough proximal screws to capture the fragment. **B, C** The reduction was lost within the first 2 weeks postoperatively and the patient required revision surgery.

## PEARLS AND PITFALLS

### Soft tissue management

Wound-healing problems are common; therefore, whenever possible we prefer a posteromedial incision. This avoids having a wound over the area of maximum tension. Full-thickness flaps are elevated to expose the fracture. The ulnar nerve is usually left *in situ* and protected throughout the procedure. Limit self-retaining retractors and electrocautery injury to the incision margin.

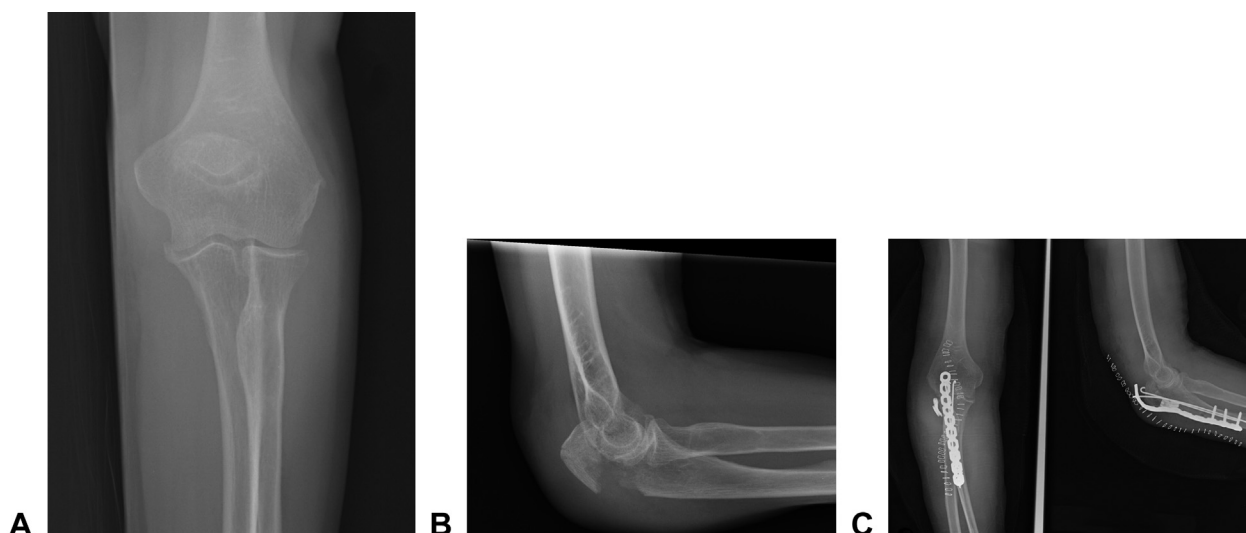
Hardware irritation is always an issue and can be minimized by burying the hooked K-wires or screw below the triceps, which is then sutured over them. Twisted wires must be directed away from skin and covered with the aponeurosis or muscle belly of the flexor carpi ulnaris or extensor carpi ulnaris. Absorbable subcutaneous sutures and a layered skin closure are maintained until wound healing is complete.

### Reduction

When performing the reduction, it is mandatory to assess the cartilage and intermediate fragments to

ensure joint congruence. Central comminution is common and fragments that seem too small should never be thrown away. Loss of fragments will alter the radius of curvature of the notch and change the articulation with the humerus. If part of the joint surface is loose it can be held in place with small-diameter, fully threaded K-wires that can be placed from inside the fracture and then cut flush and buried with use of a tamp. The fracture is then reduced with the K-wires inside, allowing them to become part of the permanent fixation (Fig. 3). If pieces are lost or not recoverable, consider using bone graft to preserve the curvature of the notch.

In the absence of comminution, the entire construct can be held with a pointed reduction forceps. It is employed by placing 1 point in the proximal fragment and then drilling a small hole in the subcutaneous border of the ulna to allow secure placement of the other point of the forceps. Unicortical mini fragment plates are another option to hold provisional reduction of small comminuted fragments. Because these plates are small and low-profile, they are placed along the medial or



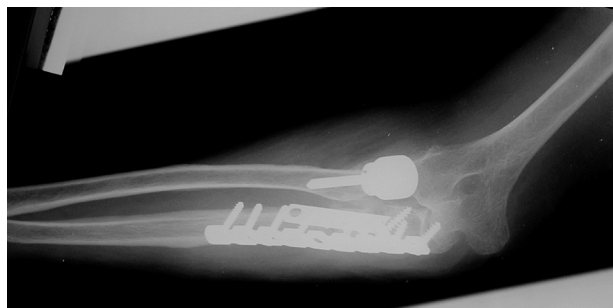
**FIGURE 8:** **A, B** Preoperative radiographs of a 72-year-old woman with known severe osteoporosis was treated with hybrid fixation including K-wires and polyethylene-coated nylon tension band and a plate for reinforcement shown in **C**.

lateral borders of the proximal ulna and augment the primary fixation (Fig. 6). A medial or lateral arthrotomy of the elbow joint allows for direct visualization of the articular surface to assess adequacy of joint reduction and should be confirmed with fluoroscopy.

#### Hardware selection

Loosening and proximal migration of the K-wires is common. Advancing the wires by malleting rather than drilling, as described above, will enhance the security of the intramedullary fixation even in osteopenic patients and help reduce this complication. In addition, one can twist the proximal end of the wire into an O shape and pass the tension wire through the eyelet, effectively holding the K-wire in place with the tension band. There are also commercially available K-wires with eyelets prefabricated into the wire (Fig. 3).

Proper tensioning a figure-of-8 wire is technically challenging. It is difficult to both teach and learn because of a tendency to either undertwist or overdo it and break the wire (Fig. 10). Also, any kink in the figure-of-8 passage will decrease the equalization of tension in the construct despite 2 twisting points. Therefore, we are now using a high-molecular-weight polyethylene-coated nylon cable (SuperCable; Kinamed Corp., Camarillo, CA). The locking mechanism can be easily positioned laterally where it will be least prominent, the isoelastic nature of the material has a more uniform tension, and the nylon is softer than traditional wire and seems to be better tolerated by patients along the posterior border of the ulna (Fig. 11).



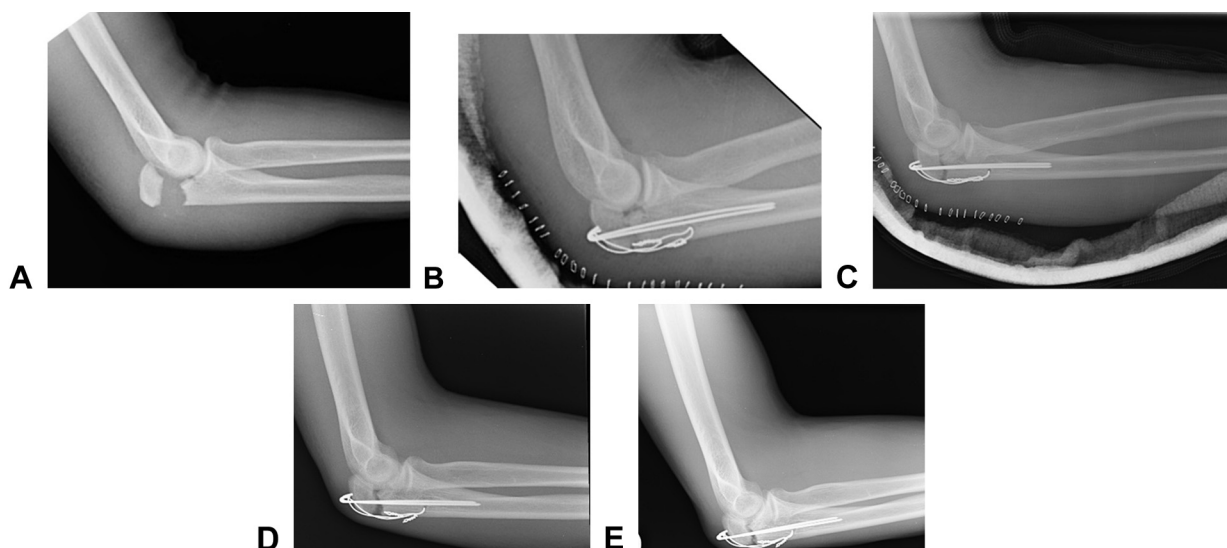
**FIGURE 9:** A comminuted fracture dislocation that was treated with dorsal and lateral plating of the olecranon.

#### Postoperative care and rehabilitation

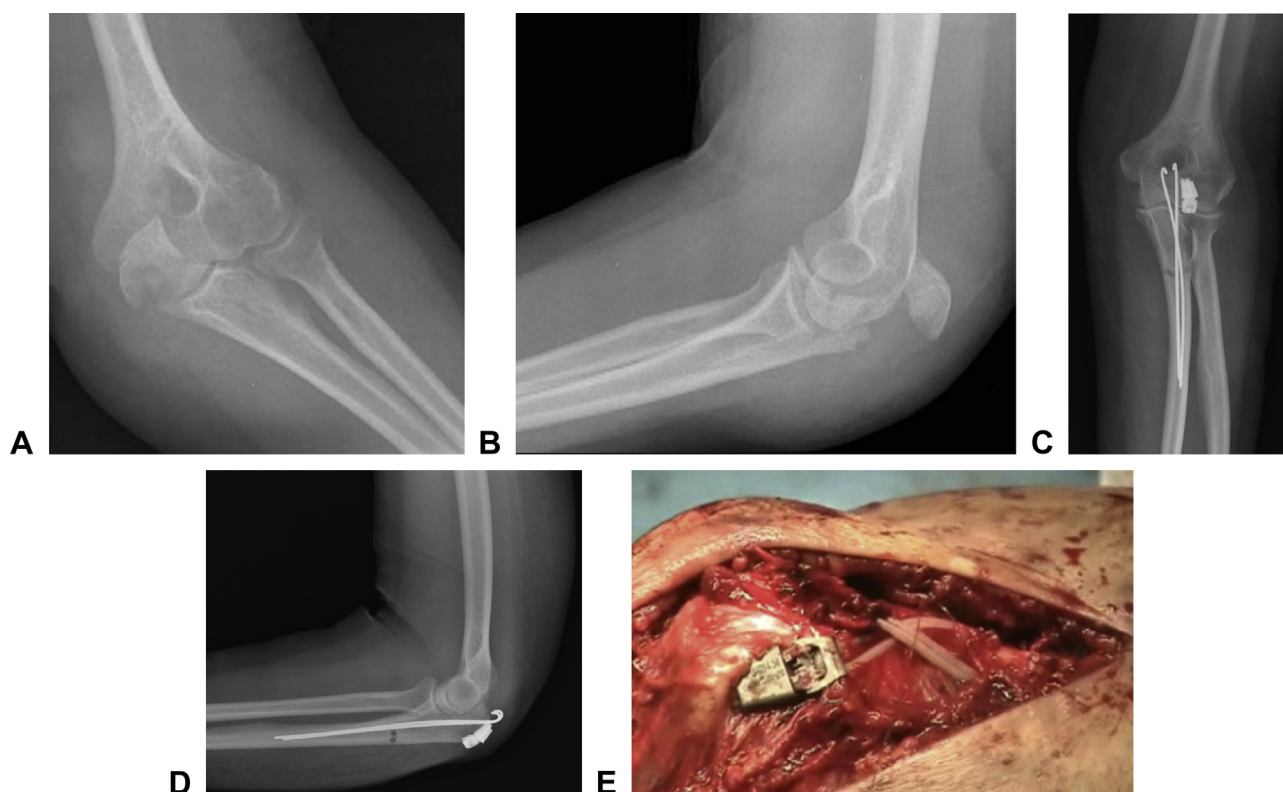
A well-padded splint with the elbow flexed at 45° is recommended for the first 3 weeks to allow for wound healing and for the fracture to begin healing. After 3 weeks sutures are removed and patients are transitioned to functional bracing so they can begin guided range of motion exercises. In severely comminuted fractures, in addition to splinting, we will occasionally inject the triceps with 100 U botulinum toxin A. This provides reversible weakening of the elbow extensor to help preserve the reduction.

#### COMPLICATIONS

Potential complications of olecranon fractures include poor wound healing, loss of reduction, and malunion. Painful hardware requiring removal remains the largest single complication, with rates reported as high as 82.3%.<sup>6</sup> In addition, stiffness is common and patients should be counseled to expect some degree of loss of motion regardless of how the injury is



**FIGURE 10:** **A** An 18-year-old man fell from scaffolding and sustained a displaced fracture. **B** At 1 week the reduction was maintained but **C** by 2 weeks the fracture was starting to displace owing to improper tensioning of the tension band wire. **D** This worsened by 1 month and **E** by 3 months postoperatively he went on to nonunion.



**FIGURE 11:** **A, B** Injury radiographs of a 70-year-old woman who sustained an olecranon fracture during a fall onto a flexed elbow. **C, D** She underwent open reduction internal fixation with K-wires and a tension band using a polyethylene-coated cable in a figure-of-eight for the tension band. **E** The crimping device for the cable was left on the proximal-lateral border of the ulna to minimize soft tissue irritation.

treated. Heterotopic ossification is rare but has been reported, as have postoperative ulnar neuropathies. Infection is also a potential problem and most often is related to soft tissue compromise.

Although olecranon fractures are common and often have satisfactory outcomes, they are challenging. For transverse fractures we prefer K-wire and tension cables instead of traditional 18-gauge wire. In our

experience the need for secondary surgery for hardware removal is less often than with twisted wire fixation. In complex fracture patterns plates provide more options for multiplanar fixation. The guiding principle is to restore a congruent humeroulnar joint and allow restoration of upper extremity function.

## REFERENCES

1. Morrey BF. Current concepts in the treatment of fractures of the radial head, the olecranon, and the coronoid. *Instr Course Lect.* 1995;44:175–185.
2. Duckworth AD, Bugler KE, Clement ND, Court-Brown CM, McQueen MM. Nonoperative management of displaced olecranon fractures in low-demand elderly patients. *J Bone Joint Surg Am.* 2014;96(1):67–72.
3. Gartsman GM, Sculco TP, Otis JC. Operative treatment of olecranon fractures: excision or open reduction with internal fixation. *J Bone Joint Surg Am.* 1981;63(5):718–721.
4. Matthews F, Trentz O, Jacob AL, Kikinis R, Jupiter JB, Messmer P. Protrusion of hardware impairs forearm rotation after olecranon fixation: a report of two cases. *J Bone Joint Surg Am.* 2007;89(3):638–642.
5. Cannada L, Loeffler B, Zadnik MB, Eglseder AWA. Treatment of high-energy supracondylar/intercondylar fractures of the distal humerus. *J Surg Orthop Adv.* 2011;20(4):230–235.
6. Chalidis BE, Sachinis NC, Samoladas EP, Dimitriou CG, Pournaras JD. Is tension band wiring technique the “gold standard” for the treatment of olecranon fractures? A long term functional outcome study. *J Orthop Surg Res.* 2008;3:9.