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Transulnar basal coronoid fractures – Surgical tips and tricks

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Elbow fracture dislocations are difficult problems to manage, given the intricacies of fracture fixation, maintenance of joint stability and congruity, and avoidance of post-traumatic and post-operative complications including stiffness, instability, arthritis, heterotopic ossification, and neuropathy (among others).[3-5,8,12,14] In addition, surgical techniques and outcomes currently published are obscured by the absence of a sufficiently detailed and comprehensive classification system for proximal ulnar fractures and associated injuries.[10,13,15]

Recently, the authors' institution has adopted a classification system which groups elbow fracture-dislocations into four general categories: terrible triad fractures (and variants), Monteggia fracture dislocations (and variants), transolecranon fracture dislocations (and variants), and transulnar basal coronoid (TUBC) fractures. If the dorsal cortex of the ulna is intact, the injury falls into the category of terrible triad variant. If the dorsal cortex of the ulna is fractured, the other three categories depend upon the presence or absence of a coronoid fracture and relative location of the proximal ulnar fracture. If the coronoid is attached to the ulnar metaphysis, it is considered a transolecranon fracture dislocation. If the coronoid is attached to the olecranon, it is considered a Monteggia variant. Finally, if the coronoid is attached to neither the metaphysis nor the olecranon (i.e., it is a separate fragment), it is classified as a TUBC fracture.[2] One rationale for use of this "coronoid centric" classification system is that it focuses on the critical nature of the coronoid reduction and fixation. In most cases, this will be the major driver of the final outcome. Öztürkmen et al[9] published outcomes from eighteen patients with olecranon fracture-dislocations, noting the importance of fixation of the coronoid fragment for elbow stability. Similarly, in their outcomes from thirty-five patients with "transolecranon fracture dislocations," Haller et al[5] noted that twenty-three of those patients had associated coronoid fractures. Those patients with associated coronoid fractures, radial head fractures, distal humerus fractures or ligamentous injuries had inferior QuickDASH scores compared with patients with isolated transolecranon fractures.

Advanced imaging in the form of computed tomography (CT) scan with three-dimensional reconstruction should be obtained in these cases in order to aid in surgical planning. The three-dimensional CT is important for understanding the overall geometry of the fracture patterns, but it is critical to study the two-dimensional images to ensure preoperative understanding of any fracture lines that are "hidden" within the three-dimensional reconstruction. Management of TUBC fractures is dependent on anatomic and stable fixation of the coronoid fragment(s), restoration of the articular surface, and anatomic reconstruction of the proximal ulna (and proximal ulnar dorsal angulation).[11] The following cases represent technical options for TUBC fractures, including indications for multiple approaches for supplemental reduction and fixation.

Technical note

Assessment of coronoid fracture location

The strategy for fragment specific fixation begins with careful assessment of the coronoid fracture morphology. Coronoid fracture lines through the base of the coronoid, or with minimal or no dorsal extension, will typically need a separate, more anterior approach (Fig. 1, red and yellow zone). If the coronoid fracture

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line extends more dorsally, it can oftentimes be accessed from the dorsal exposure (Fig. 1, green zone). In these cases, minifragment plate or lag screws from the dorsal cortex can be used to fix following reduction. If a more anterior approach is needed, the authors prefer an extended anteromedial exposure [7] through a separate incision. We prefer to do this step last, as in many cases it is difficult to get this fragment perfectly reduced while the dorsal cortex of the ulna is fractured and unstable. This strategy is based on the preoperative imaging and precedes surgical management.

Positioning

The author's preference is to position the patient laterally, with the arm over a radiolucent arm holder. Patients may also be positioned prone or in supine position with the operative arm placed across the chest. In the lateral position, an elevated radiolucent arm board is utilized for the operative arm and the height is adjusted to ensure the humerus is parallel with the floor. The contralateral arm is supported by plexiglass that prevents excess glenohumeral external rotation. The C-arm is brought in from cephalad to allow for anteroposterior and lateral radiographs to be taken without manipulating the operative limb. It is important to ensure that the proximal aspect of the operative table is radiolucent. If it is not, a radiolucent foot extension is utilized, and the patient's head is placed on the distal aspect of the table.

Surgical approaches

Three surgical approaches "windows" are typically used to fix TUBC fractures. These windows are accessed in a "fragment specific" manner. In the vast majority of cases, a direct posterior approach will be needed to reduce and fix the "transulnar" portion of the fracture. Laterally, a Kocher, Kaplan, or extensor digitorum communis (EDC) split based exposure can aid fixation or replacement of the radial head, and lateral ulnar collateral ligament (LUCL) repair. Medially, rigid fixation of the coronoid is critical. This can be completed with buttress plating particularly for fractures with minimal dorsal extension less accessible from the posterior approach, or with screw fixation from the dorsal ulna. Taylor-Scham, approaches through the floor of the ulnar nerve, and the extended anteromedial approach can be utilized to improve exposure and fixation of these critical fragments. These approaches can be completed through separate incisions, or by raising flaps through the posterior approach (in most cases, the authors prefer separate approaches).

Fracture fixation approach

After making the plan for the coronoid, we typically begin with a posterior based approach. In many cases, the ulnar nerve is identified and protected. Once the ulnar nerve is protected, the sequence of fracture management is largely dependent on severity of comminution of the dorsal proximal ulna (olecranon fracture), severity of comminution of the coronoid fragment, and the presence of an unstable lateral column (radial head fracture not amenable to fixation). Typically, the first goal is to attempt to obtain length stability of the forearm. In some cases, soft tissue disruption on the lateral aspect of the ulnar fracture allows "shotgunning" of the radial head through the fracture. This can facilitate fixation or arthroplasty. In the setting of less dramatic soft tissue disruption, a lateral based approach (typically an EDC split) can be made to repair or replace the radial head. Careful attention must be paid to ensure appropriate sizing of the radial head. This is typically

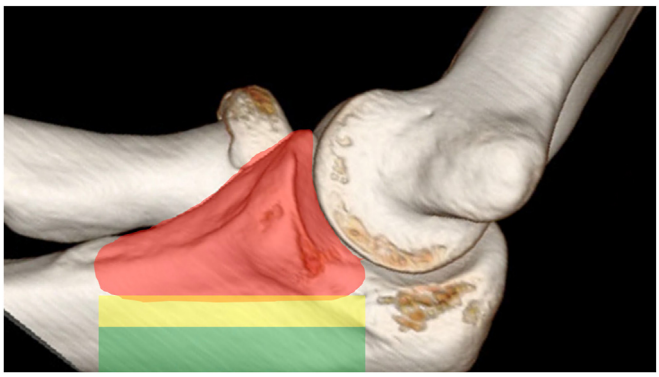

Figure 1 Red, yellow, and green zones dictating the feasibility of reducing and fixing a coronoid fracture line through a dorsal approach (*green*) or necessitating the use of a second, anteromedial approach (*red*, *yellow*).

completed by assembling the radial head on the back table and paying careful attention to the minor diameter of the radial head arthroplasty, as well as the neck length. Once a size is chosen, it can be placed, and the ulna can be reduced. This will allow direct visualization of the lesser sigmoid notch, the most reliable indicator of radial head length (confirmatory radiographs should be used, but direct visual assessment of the lesser sigmoid notch is most accurate).[1]

If the radial head sizing can be confidently assessed, the final radial head implant can be placed. In the setting of profound comminution, a trial can be placed to aid in ulnar fracture reduction. The remainder of the ulnar comminution should be sequentially reduced and fixed, typically through a combination of lag screws, minifragment plates, and in most cases a precontoured olecranon locking plate. If the fracture line of the coronoid extends posteriorly (green box in Fig. 1), this can be reduced with the posterior ulnar exposure. In many cases, this fragment will be critical to ensure an anatomic reduction of the dorsal ulna. Careful visual and radiographic scrutiny should be given to this reduction. Minifragment plating can be used to secure this reduction, in addition to free lag screws or screws through the dorsal plate. If the coronoid fragment is small (red or yellow box in Fig. 1), a separate extended anteromedial approach is made, and the fragment is reduced. Provisional fixation of the ulnar fracture is advised here, to ensure that small malreductions are not accepted on the volar side of the fracture. Once the coronoid is reduced and fixed with minifragment plates or a precontoured coronoid plate, final fixation can be placed in the ulnar fracture.

Finally, ligament repair is completed. In the vast majority of cases, the LUCL will need to be repaired to the humeral origin. In these cases, careful scrutiny should be made of the preoperative CT to assess preoperative CT to assess for lateral or medial ligament avulsions off the crista supinatoris or sublime tubercle, respectively.

Prior to case completion, it is important to ensure that none of the screws heading towards to coronoid have either entered the joint. Furthermore, it is important to remove the operative limb from the padded stand to assess the stability of fixation in deep flexion and extension. Next, triceps off-loading sutures are utilized to reduce the distraction forces caused by the elbow extensor mechanism on the olecranon fragment.[6] This is done by running a high tensile nonabsorbable suture through the distal 2 cm of the triceps tendon in a locking fashion, using at least one suture on each side of the triceps tendon. Depending on plate design, these sutures can be secured to the plate either through an empty screw hole,

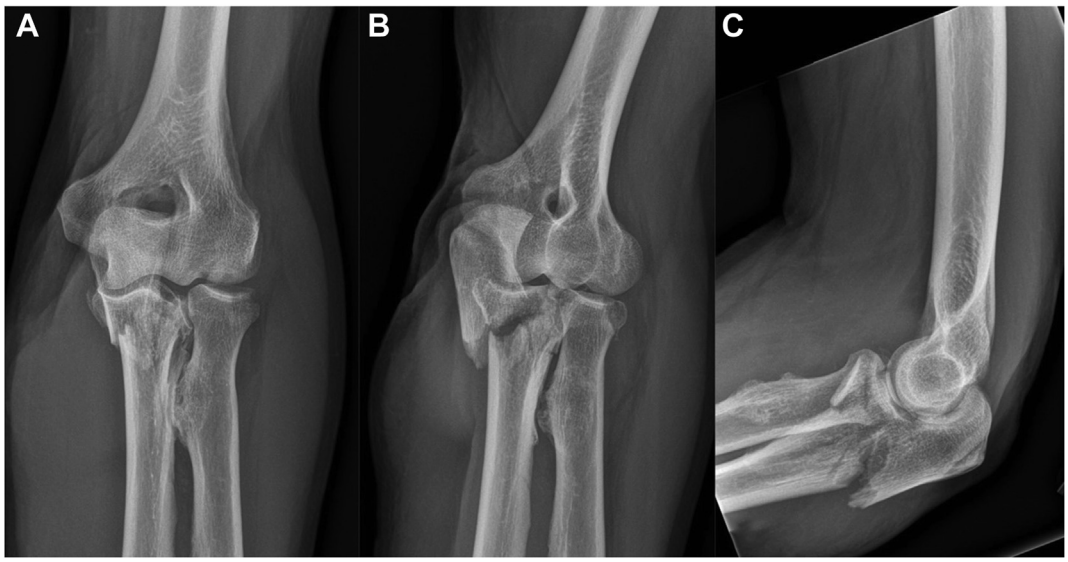

Figure 2 Case 1 – Anteroposterior (**A**), oblique (**B**), and lateral (**C**) radiographs after sustaining a mechanical fall.

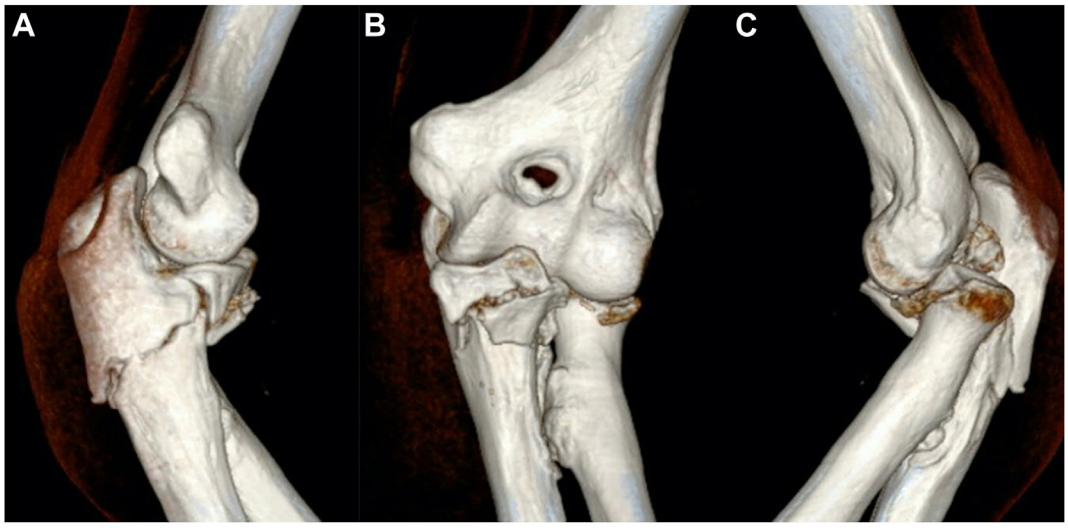

Figure 3 Case 1 – Select 3D reconstructions of elbow CT scan after sustaining a mechanical fall. (**A**): medial sagittal view demonstrating olecranon fracture dorsally. (**B**): Anterior view of the proximal volar fracture involving the anteromedial coronoid and metaphyseal comminution. (**C**): lateral sagittal view demonstrating a comminuted radial head fracture dislocation. *3D*, three-dimensional; *CT*, computed tomography.

dedicated suture passing holes, passed underneath the plate, or through a small hole drilled transversely through the dorsal ulnar cortex and tied over the plate.

If formal medial approaches to the coronoid were utilized, it is important to close the dorsal facial layer to prevent flexor-pronator muscle herniation which may cause subsequent discomfort. Finally, the ulnar nerve is once again checked at the end of the case to ensure it is stable and not subluxating over the medial epicondyle. In the presence of instability/subluxation, an anterior subcutaneous or submuscular transposition would be completed, based on patient factors.

Given the severity of soft tissue injury, and the high risk of wound issues around the elbow, a short period of soft tissue rest is typical. We typically splint the elbow in flexion for one week. For weeks 1 through 6, a supine active assisted range of motion protocol is encouraged. This can offload the medial and lateral ligaments. At 6 weeks, the sling is removed, and active and passive range of motion are encouraged. At 3 months, strengthening is initiated.

Case examples

Case 1

A 74-year-old male patient sustained a mechanical fall while walking his dog. Initial radiographs (Fig. 2) in the emergency department demonstrated a complex proximal ulnar fracture dislocation with radial head fracture. Subsequent CT scans (Fig. 3) demonstrate a TUBC fracture with associated radial head fracture. The patient was positioned in the operating room in the lateral position as described above. A posterior midline skin incision was used and the olecranon fracture was directly visualized (Fig. 4, *A*) and reduced using a reduction clamp (Fig. 4, *B*). A 6.5 mm cannulated screw system was used by first passing a guidewire into the

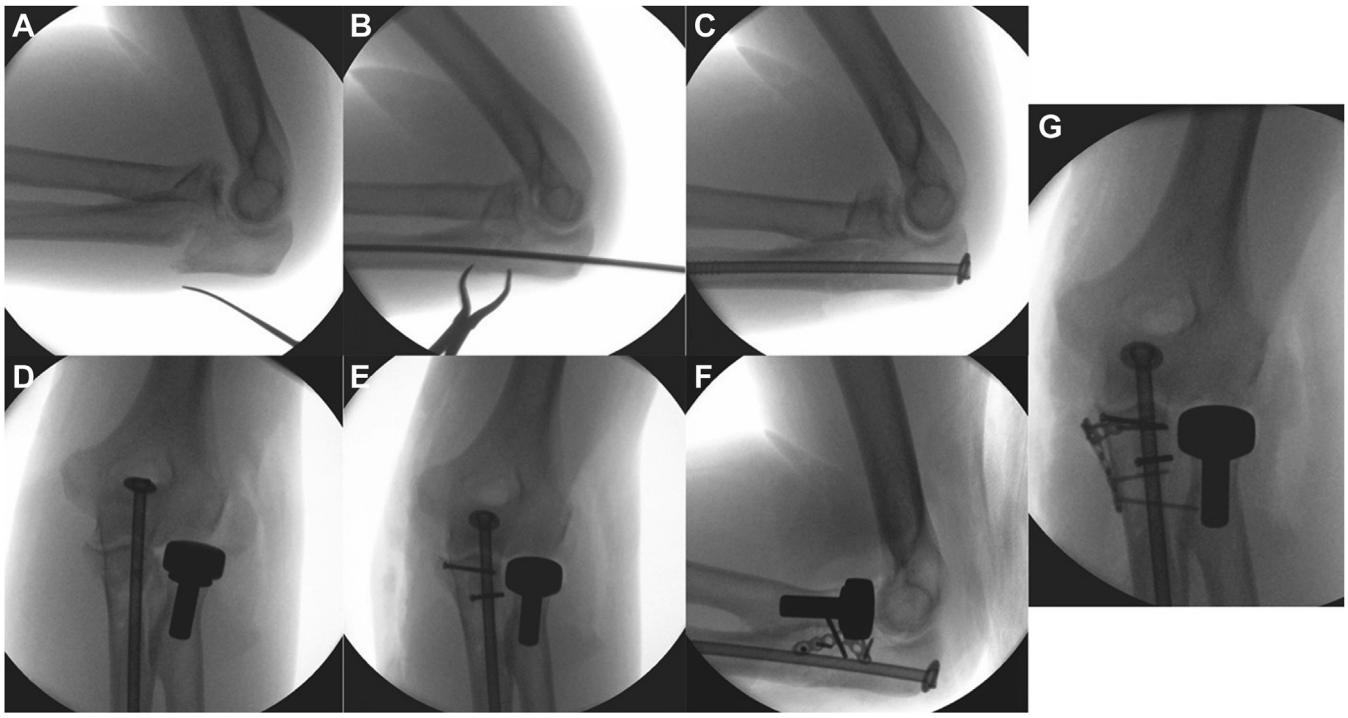

Figure 4 Case 1 – Intraoperative radiographs. (**A**): lateral view of the olecranon fracture prior to reduction. (**B**): Olecranon fracture reduction maintained with clamp and guide wire passed through ulnar canal. (**C**): 6.5 mm partially threaded cancellous screw passed over the guide wire along with washer to compress the fracture. (**D**): Radial head replaced. (**E**): Two independent lag screws were used to secure the two large coronoid fragments. (**F**): lateral view demonstrating buttress plate fixation of the anteromedial coronoid. (**G**): anteroposterior view demonstrating buttress plate fixation of the anteromedial coronoid.

ulnar canal from the proximal olecranon (Fig. 4, *B*). A 6.5 mm cannulated partially threaded cancellous screw (with washer) was placed into the canal, compressing the fracture (Fig. 4, *C*). An EDC splitting approach was used towards the radial head and it was found to be comminuted/impacted, and was therefore excised. A smooth, polished radial head arthroplasty component was placed after correct sizing was determined relative to the proximal radioulnar joint under direct visualization (Fig. 4, *D*). Next, the ulnar nerve was dissected and protected. Because the coronoid was unable to be visualized from the dorsal approach (red zone), an extended anteromedial approach was utilized to approach the coronoid fracture. Two large coronoid fragments were reduced using independent 2.4 mm lag screws (Fig. 4, *E*). Finally, a mini-fragment T-plate was utilized as a buttress plate to incorporate the anteromedial coronoid comminution after reduction. The plate was under contoured and cortical screws were placed at the level of the ulnar shaft to allow the plate to buttress the fracture (Fig. 4, *F* and *G*). Follow-up at six months post operatively demonstrates a concentric joint with union achieved (Fig. 5).

Case 2

A 57-year-old female presented to the emergency department with severe elbow pain after tripping and falling onto an outstretched right arm. Her initial radiographs showed a TUBC fracture, with a transverse fracture through the central portion of the olecranon, an associated comminuted coronoid fracture, as well as a small fracture of the volar rim of the radial head (Fig. 6). After reduction and splinting, a CT scan was performed in order to better characterize the fracture fragments, and three-dimensional reconstructions of the CT were obtained for preoperative planning purposes (Fig. 7). She was brought to the operating room and positioned in the lateral position as described above. Surgery was performed 4 days postinjury. Notably, she had already developed fracture blisters which were avoided during the approach. The initial incision was positioned over the medial aspect of the elbow, and significant soft tissue disruption from the trauma was noted. The ulnar nerve was identified and mobilized proximally and distally in order to create a safe approach to the anteromedial facet (fracture in the red zone – unreachable from a dorsal approach). A Taylor Scham approach was made to the ulna, exposing the medial aspect of the transverse fracture as well as the coronoid fracture. The coronoid fracture was reduced and two 2.4mm screws were used to fix this fragment to the ulnar shaft (Fig. 8, *A*). The olecranon fracture was quite unstable. A clamp was placed medially to compress the fracture, and a 2.7mm plate was placed medially (Fig. 8, *B* and *C*). Laterally, a Kocher approach was made, again with substantial soft tissue injury noted including avulsion of the LUCL from the humerus, in addition to avulsion of portions of the common extensor. The radial head fracture fragments were too small to be fixed but the size of the fracture did not necessitate an arthroplasty, so they were excised. A second 2.7mm plate was placed on the lateral side of the ulna, with one of the screws placed to engage the proximal aspect of the coronoid fracture fragment (Fig. 8, *D* and *E*). The articular surface was congruent on fluoroscopic imaging. Given the severity of the lateral ligament injury, additional suture fixation was utilized from the LUCL origin to the insertion on the ulna. The stability of the joint was then tested and found to be satisfactory (Fig. 8, *F*). The ulnar nerve was subcutaneously transposed anteriorly. Radiographs one week postoperatively demonstrated the fracture in good alignment and a congruent joint surface. She had no complications, and at final follow-up she had minimal pain, and a range of motion arc of 5 degrees short of full extension to 140 degrees of flexion as well as full pronosupination.

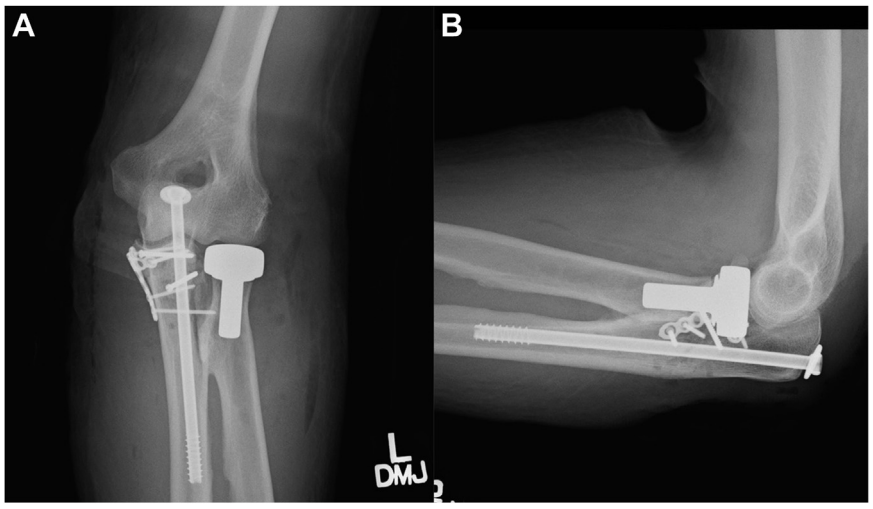

Figure 5 Case 1 – Six months postoperative anteroposterior (**A**) and lateral (**B**) radiographs demonstrating a united fracture with a concentric joint.

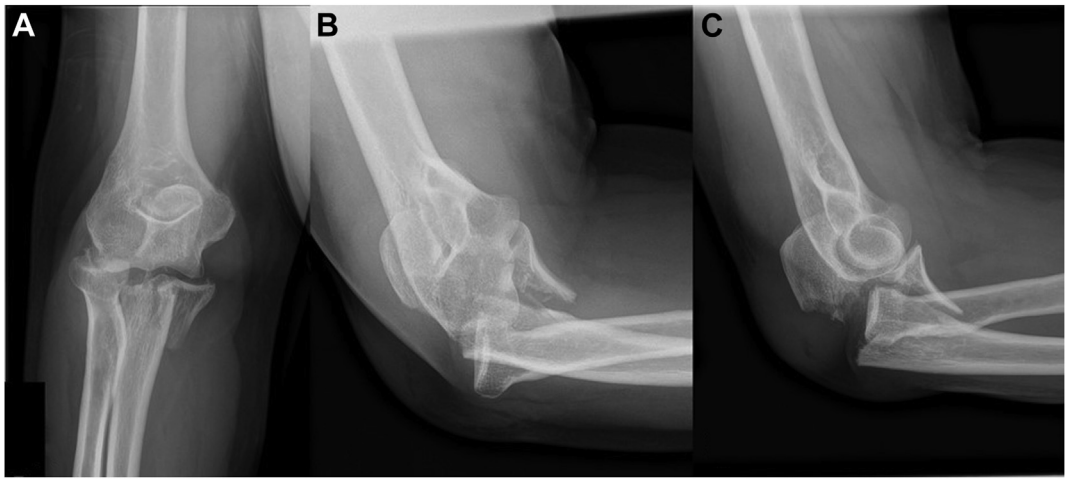

Figure 6 Case 2 – Anteroposterior (**A**), oblique (**B**), and lateral (**C**) radiographs at the time of initial injury.

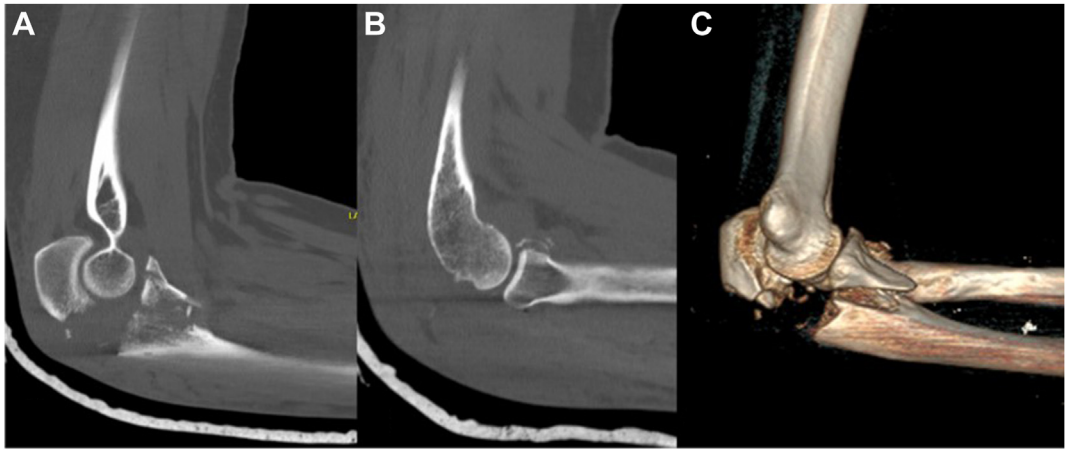

Figure 7 Case 2– Sagittal CT images demonstrating the complex fracture pattern for this transulnar basal coronoid fracture (**A**) as well as the associated small fracture of the volar rim of the radial head (**B**). The three-dimensional reconstruction is again helpful for preoperative planning (**C**). *CT*, computed tomography.

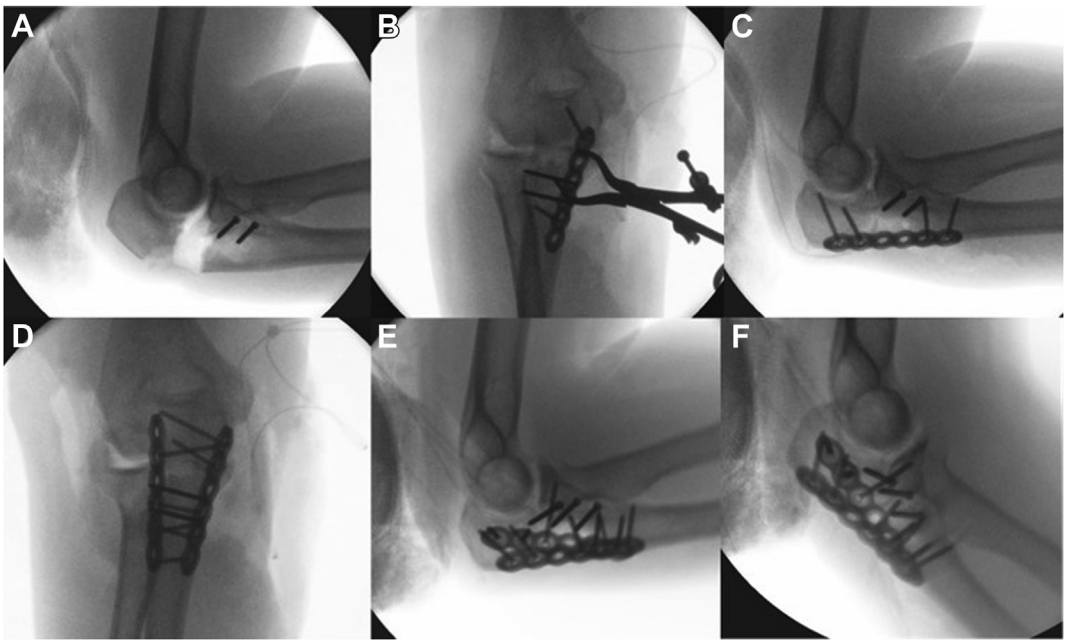

Figure 8 Case 2 – Intraoperative fluoroscopic images demonstrating fixation of the anteromedial facet coronoid fracture to the ulnar shaft (**A**). A medial clamp was used to compress the fracture and a medial plate was placed (**B** and **C**). Subsequently a second plate was placed laterally (**D**), with one screw from this plate placed into the coronoid fracture fragment (**E**). The elbow was stable to flexion, extension, varus and valgus stress (**F**).

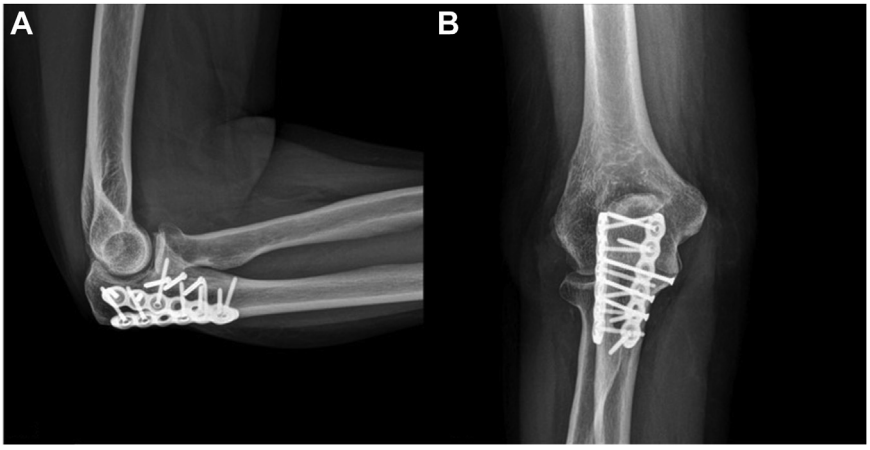

Figure 9 Case 2 – Lateral (**A**) and anteroposterior (**B**) of the elbow seven months postoperatively demonstrating the fracture in good alignment, a congruent articular surface, and intact hardware.

Her x-rays at final follow-up at 7 months postoperatively showed the fracture healing, intact hardware, a congruent joint surface and no evidence of early post-traumatic arthritis (Fig. 9).

Conclusion

A systematic approach to TUBC fractures can facilitate anatomic reduction and acceptable outcomes. Management begins with careful review and scrutiny of axial imaging. Three dimensional reconstructions of the elbow can help increase the surgeon's understanding of the fracture fragments. The coronoid is the critical fracture fragment. If the coronoid can be accessed through the dorsal approach, this fragment can be reduced and fixed with independent lag screws, mini fragment fixation, and/or screws through the olecranon plate. If the fracture is more volar, a separate anteromedial approach is completed, typically through a separate skin incision. Laterally, an EDC splitting approach can enable fixation or replacement of the radial head, as well as LUCL repair. A short period of soft tissue rest is followed by a supine range of motion protocol.

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