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Staged allograft fixation for complex open distal humerus fracture with ulnohumeral bone loss in a young adult: a technique guide

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Open distal humerus fractures are a complex problem for the orthopedic surgeon. When articular fragments can be preserved, the gold standard in a young patient is to obtain anatomical reduction of the joint with open reduction and internal fixation (ORIF). The presence of bone loss presents a further challenge. In the elderly patient, a total elbow arthroplasty can provide reliably functional outcomes.[5,8] However, this is often not appropriate in the younger patient due to required weight bearing restrictions and the inevitable need for future revisions.

In the setting of substantial bone loss, options include endoprosthesis and shortening with osteosynthesis.[6,11] With less severe bone loss, ORIF with allograft, autograft, arthrodesis, or hybrid internal and external fixation have been described. No consensus currently exists on the optimal treatment in this scenario, and the literature is limited.

Prior technique guides have described allograft fixation for open distal humerus fractures; however, none have described an operative technique in detail for use as an index procedure in a young adult with significant ulnohumeral joint bone loss without relying on specialized methods. The purpose of this technique guide was to describe a widely applicable technique for allografting of a complex open distal humerus fracture with significant soft-tissue contamination and ulnohumeral joint bone loss.

Case

The patient is a 23-year-old male who was involved in a motor vehicle collision and sustained a grade IIIa open distal humerus fracture—dislocation with ulnar shaft fracture as well as bilateral pulmonary contusions and closed left proximal femoral shaft fracture. Injury radiographs are demonstrated in Fig. 1. He was stabilized initially at an outside hospital with irrigation and débridement (I&D) of his distal humerus with splint application and femoral traction pin. His open distal humerus wound was closed primarily and there was no soft-tissue defect. He returned to the operating room for repeat I&D and external-fixator placement of his distal humerus, ORIF of left ulnar shaft fracture, and left femoral intramedullary nailing. He was then transferred to our facility for further care.

Initial evaluation following transfer revealed that the patient was neurovascularly intact to his left upper extremity status post external fixation. A preoperative computed tomography (CT) was obtained for further clarification of the fracture. The CT scan confirmed a comminuted distal humerus fracture with significant bone loss to the trochlea and olecranon, leading to the decision to manage his fracture in a staged fashion. His index procedure at our institution approached the distal humerus via the prior closed dorsal incision. The triceps was released off the proximal ulna and reflected proximally. The ulnar nerve was identified and mobilized. There was significant soft-tissue contamination, which was thoroughly débrided. The tip of the olecranon and coronoid remained intact. The fracture involved the lateral condyle but there was no bone loss of the lateral column. The lateral-collateral ligament

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Figure 1 (**A**) AP and (**B**) attempted lateral injury films of complex distal humerus fracture—dislocation with olecranon and ulnar shaft fracture. *AP*, anterior-posterior.

complex remained intact to the fractured piece. There was approximately 75% bone loss of the trochlea. The decision was made to proceed with staged fixation with ORIF of the lateral condyle and coronoid, antibiotic spacer of the trochlear defect, placement of an internal joint stabilizer elbow stabilization system (Skeletal Dynamics, Miami, FL, USA) fed through the lateral column plating, triceps advancement to the proximal olecranon plate, and splinting in extension. The internal joint stabilizer is an internal fixator device used to stabilize the unstable elbow without requiring an external fixator. Due to soft-tissue loss from prior procedures, the wound was tenuous and closed under tension. This, in combination with gross contamination, led to the decision to place the antibiotic spacer (Fig. 2). This is a well-described technique and serves to sterilize the wound with gradual elution of antibiotics and mechanically keeps the arm straight as the soft-tissue envelope heals.[3,10] It also encourages the formation of a pseudomembrane for future grafting.[12] Postoperative imaging is shown in Fig. 3. Postoperative wound checks as an inpatient on postoperative day 1 and 2 showed that he did not require further débridements prior to the next stage of his treatment, so he was discharged from the hospital with scheduled weekly follow-up appointments.

The patient was kept splinted in extension for 6 weeks to allow wound healing and was followed in clinic weekly with wound checks. After 6 weeks, the soft tissue was deemed amenable to definitive fixation with allograft arthroplasty. A CT scan of the contralateral arm was obtained for sizing of the allograft. The prior incision was reopened, and the triceps was again reflected. The ulnar nerve was identified and mobilized. The internal joint stabilizer and the cement spacer were removed, and the wound appeared clean (Fig. 4). Using a total ankle cutting jig (Infinity Total Ankle System, Wright Medical, Memphis, TN, USA), we cut out a block of bone from the distal humerus to allow for placement of the allograft (Fig. 5). The total ankle jig was again used to cut a matching block of bone from the allograft humerus at a height of 2 mm more than the defect (Fig. 6), and a medial plate was placed to secure the graft. The TiBeam (Skeletal Dynamics, Miami, FL, USA) was fed through the lateral and medial plates across the allograft to achieve compression across the reconstructed trochlea (Fig. 7). Intraoperative imaging was obtained confirming appropriate reduction. A triceps advancement down to the ulna was performed with FiberTape (Arthrex, Naples, FL, USA) through drill holes in the proximal ulna. A dynamic stress test under fluoroscopy showed that the elbow was stable to varus and valgus stress testing. There

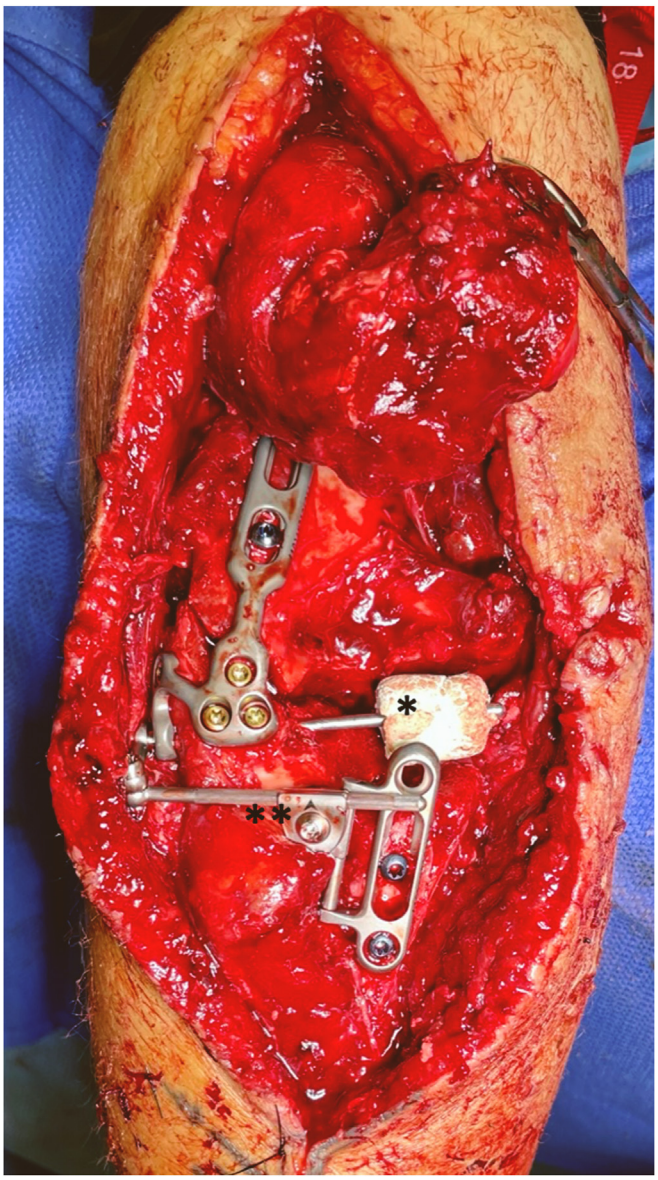

Figure 2 Status post I&D, ORIF lateral column, antibiotic spacer placement (*), and internal joint stabilizer temporary stabilization (**). *I & D*, irrigaton and débridement; *ORIF*, open reduction, internal fixation.

was no ligamentous instability. The wound was closed with nylon sutures and the patient was splinted in extension. Postoperative X-rays obtained in the recovery unit are shown in Fig. 8.

At the 2-week postoperative clinic visit, his sutures were removed and he was placed in a hinged elbow brace, allowing for 20 degrees of flexion. He was progressed with 20 degrees of flexion per week. X-rays were obtained at 6 weeks postoperatively and showed interval healing and incorporation of the graft (Fig. 9). At his 6-month follow-up appointment, he was noted to have full extension to 80 degrees of flexion, which was an appropriate range at this point. His pronation and supination was symmetric to the uninjured arm and he was pain-free. Interval X-rays demonstrated further healing without complication. His wounds healed uneventfully and there have been no complications to this point. He continued to progress with 20 degrees of added flexion per week. The patient provided verbal consent for his case to be written up in this report. Unfortunately, follow-up was lost by the 8-month postoperative time. His father informed us that he had passed due to an unrelated cause.

Discussion

This report describes a widely applicable technique for a complex distal humerus fracture with ulnohumeral bone loss and significant soft-tissue contamination in a young adult. Important aspects of this case included (1) use of the total ankle jig for accurate fitting of the graft, (2) stability obtained despite bone loss to the ulnohumeral joint, and (3) grossly contaminated wound

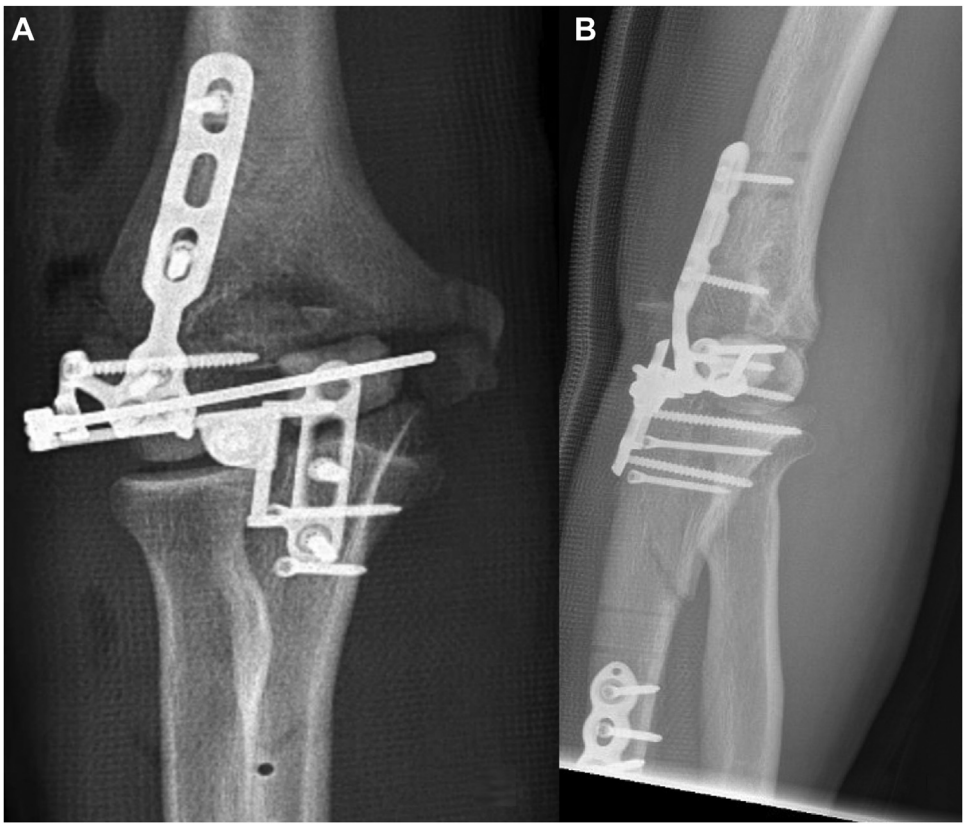

Figure 3 (**A**) AP and (**B**) lateral imaging immediately postoperatively from I&D, ORIF lateral column, antibiotic spacer placement, and internal joint stabilizer temporary stabilization. *I&D*, irrigaton and débridement; *ORIF*, open reduction, internal fixation; *AP*, anterior-posterior.

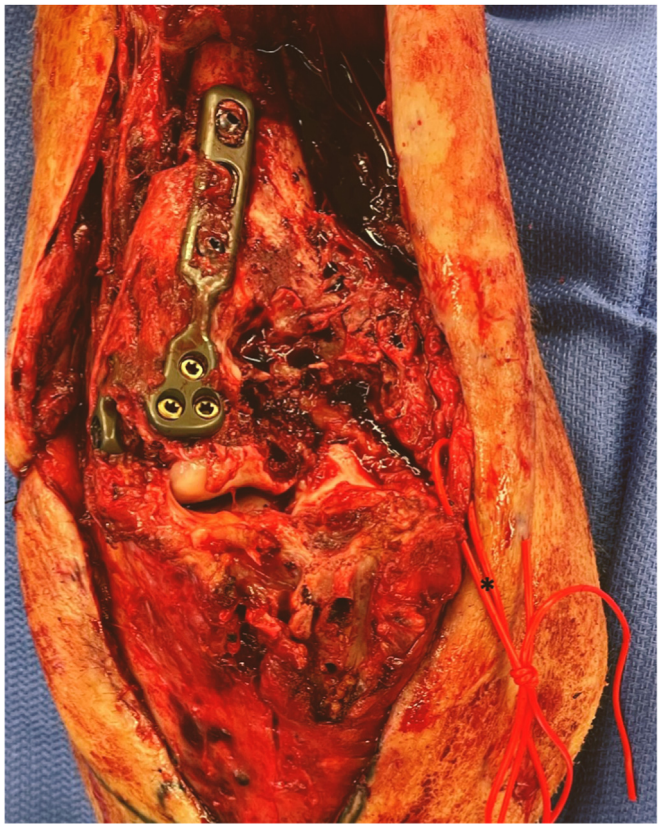

Figure 4 Intraoperative clinical picture following antibiotic spacer and internal joint stabilizer device removal, with ulnar nerve identified and mobilized (*).

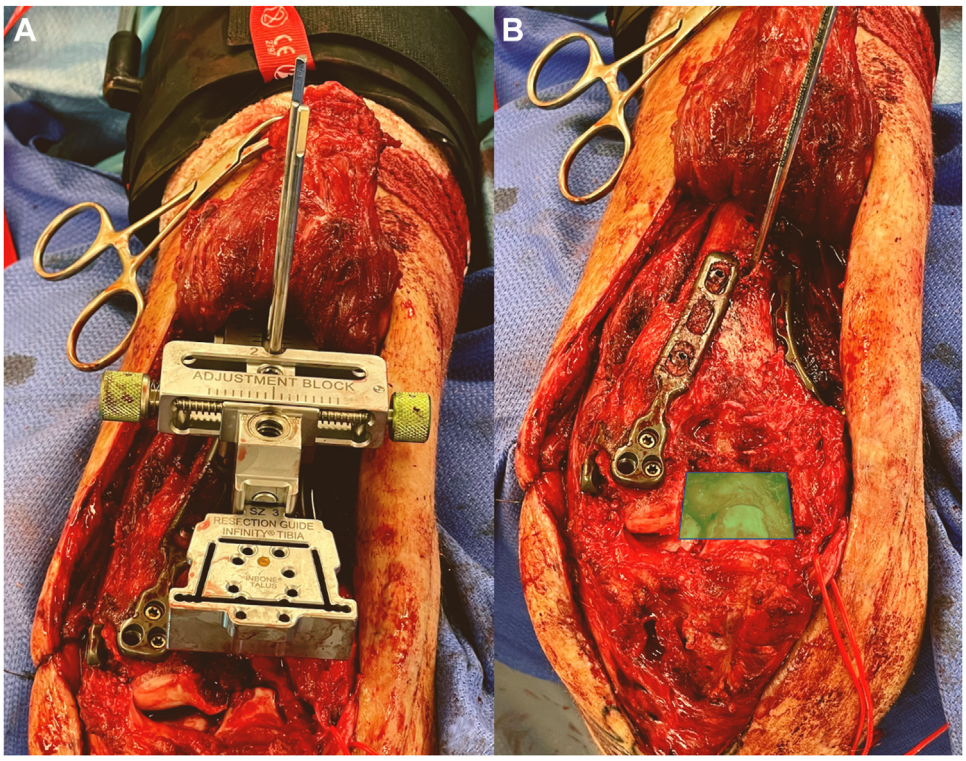

Figure 5 Placement of the total ankle cutting block (Infinity Total Ankle System; Wright Medical, Memphis, TN, USA) on the distal humerus (**A**) to cut a block for the insertion of the allograft (**B**).

managed with staged fixation with antibiotic spacer and temporary internal stabilization device.

Outcome studies for distal humerus allograft fixation are almost exclusive to post-traumatic arthritis and deformity or tumor.[1,2,4,9,16] Urbaniak et al reported a 6-year follow-up on 10 patients who underwent allograft fixation for post-traumatic changes with an average time to surgery of 2 years postinjury. While the authors reported good final range of motion and stability, complications abound and included nerve palsies, nonunion, bone resorption, and late degeneration of the joint.[16] This same cohort was followed up at 20 years.[4] The high prevalence of significant complications led the authors to conclude that allografting of distal humerus fractures for post-traumatic arthritis should only be used as a "salvage procedure." These procedures indefinitely end up with bony resorption because the allograft does not transmit pain signals but rather allows for a painless joint.[1]

However, these results are less applicable to the patient with partially preserved articular surface managed acutely with an allograft. Often patients such as ours sustain enough bone loss to render open reduction and internal fixation impossible, yet do not involve the entire articular surface. Relatively few articles describe surgical options for the management of distal humerus bone loss not amenable to primary open reduction and internal fixation.

Vascularized fibular autografting has gained attention. Advantages of this procedure include possible improved bone healing and less risk for infection or nonunion due to the use of vascularized bone.[10] Two case reports have reported satisfactory outcomes with functional range of motion at early follow-up.[10,17] However, this procedure requires specialized training in grafting and is therefore not applicable to many trauma surgeons. In addition, the procedure carries the risk of donor site morbidity.[7,15]

Iliac bone harvesting and grafting is another autografting option.[6] This has been described for reconstruction of the trochlea during the index procedure for a distal humerus fracture with bone loss. However, the technique was limited to a 2-cm defect, which would have been insufficient in cases such as ours.

Alternatively, an internal ex-fix system has been described in a recent case report of 2 patients.[13] The authors used hybrid internal fixation of one column of the distal humerus with external fixation of the other column. Both patients achieved similar grip strength to the contralateral arm and were able to return to their previous profession. However, the authors stated that their procedure would not be advised in the setting of bone loss to the ulnohumeral joint, which was the main issue in our presented case. In addition, their final radiographs show a lack of anatomic reduction inherent in external fixation, which likely contributed to the less than functional range of motion reported at final follow-up.

The most novel proposed technique involves 3-dimensional allograft transplantation for complex distal humerus fractures.[14] The obvious advantage would be a custom fit of the allograft. While this technique might show promise in the future, surgical guides are limited and it would involve a complex and significantly expensive procedure that might not be of equal benefit.

Our technique report is unique in that we describe a more applicable technique for acute fixation in the setting of massive ulnohumeral joint bone loss by using the total ankle jig for allograft cutting. This enabled us to exactly match the grafting site with the

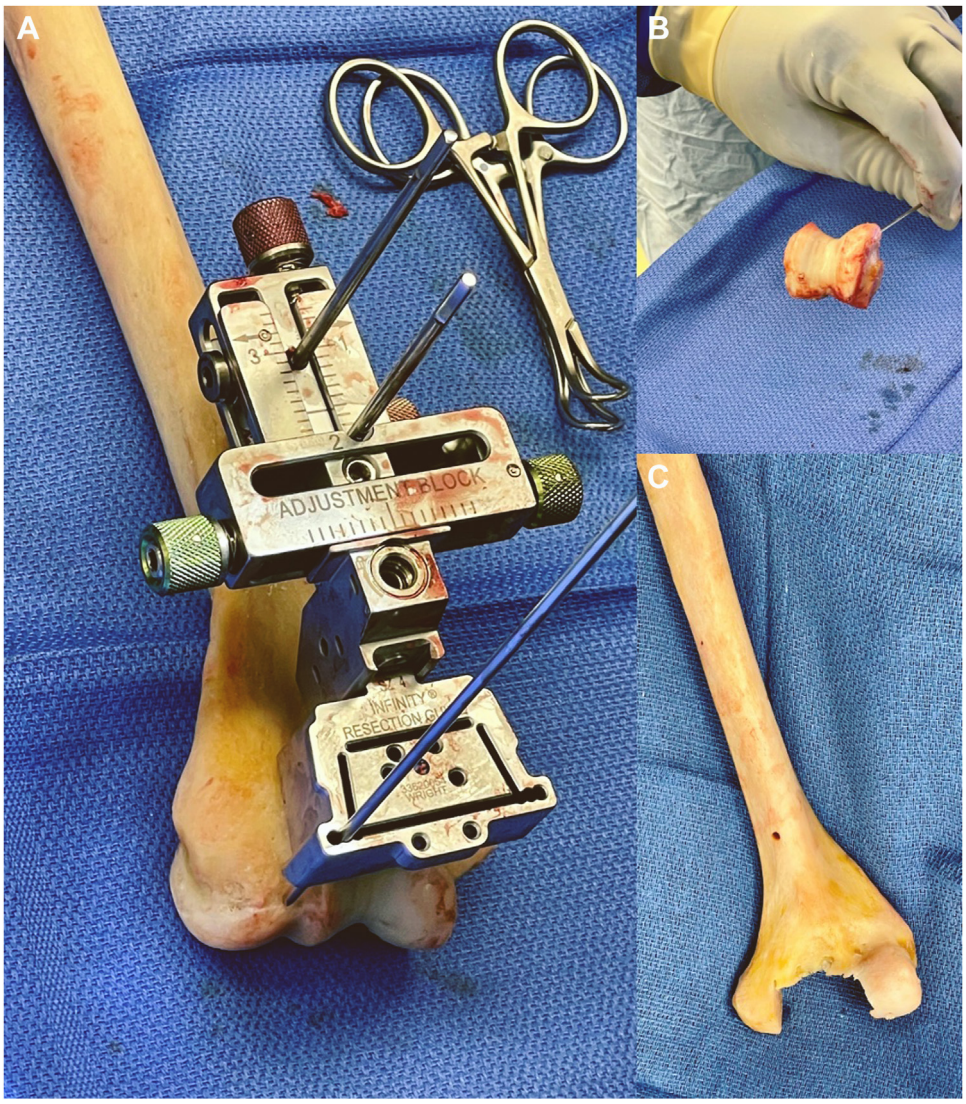

Figure 6 (**A**) Use of the total ankle cutting block (Infinity Total Ankle System; Wright Medical, Memphis, TN, USA) to cut a matching size allograft from the trochlea. (**B**) Final allograft ready for placement. (**C**) Cadaver humerus after allograft harvesting.

allograft without more complex methods. The ankle jig creates a perfect box cut and it can be anchored to the humeral shaft and fine-tuned with adjustment knobs. This is a simple technique that is familiar in principle to most orthopedic trauma surgeons.

We also describe the use of an antibiotic spacer with an internal stabilization device. This addressed the significant soft-tissue contamination that is often seen in complex distal humerus fractures while also keeping the elbow in an extended and stable position during wound healing. We believe this contributed to the successful wound healing in our patient despite requiring multiple surgeries through the same tenuous wound.

The limitations to this study are that it is a single case and that follow-up was limited to 6 months. The limited follow-up was due to the patient passing away due to an unrelated cause. However, by the time of final follow-up, the patient was continuing to progress with his range of motion and had healed his fractures and wounds appropriately.

Conclusion

We report a technique for addressing a complex distal humerus fracture in a young adult with significant ulnohumeral bone loss and soft-tissue contamination. We believe that this helps fill a void in the literature, which is lacking high-quality and widely applicable operative techniques for this problem. However, it should be noted that osteochondral allografting is not a one-time fix. The procedure is meant to provide patients with a chance of regaining appropriate function of their elbow while still preserving options for future surgeries, such as total elbow arthroplasty or arthrodesis. We also hope that this

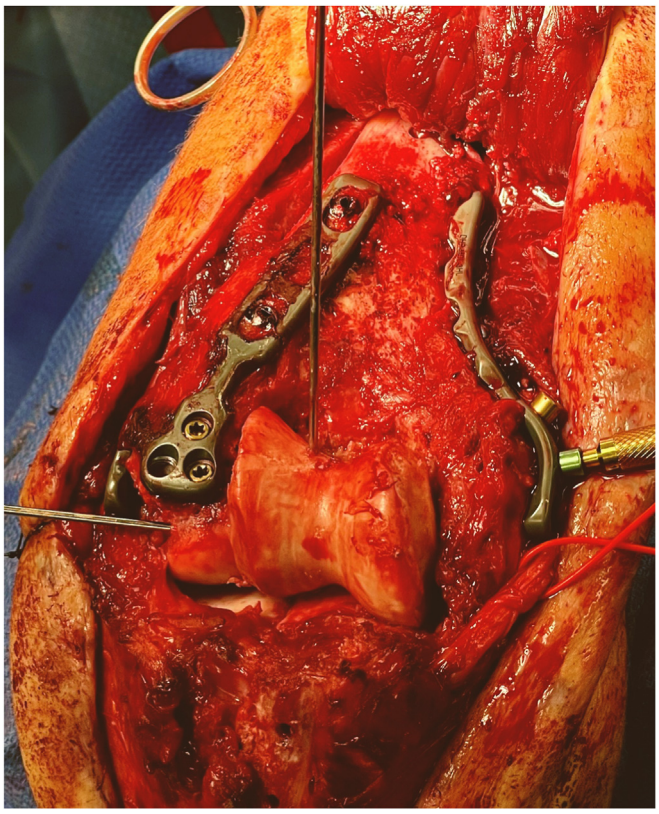

Figure 7 Placement of the allograft and fixation with medial plate.

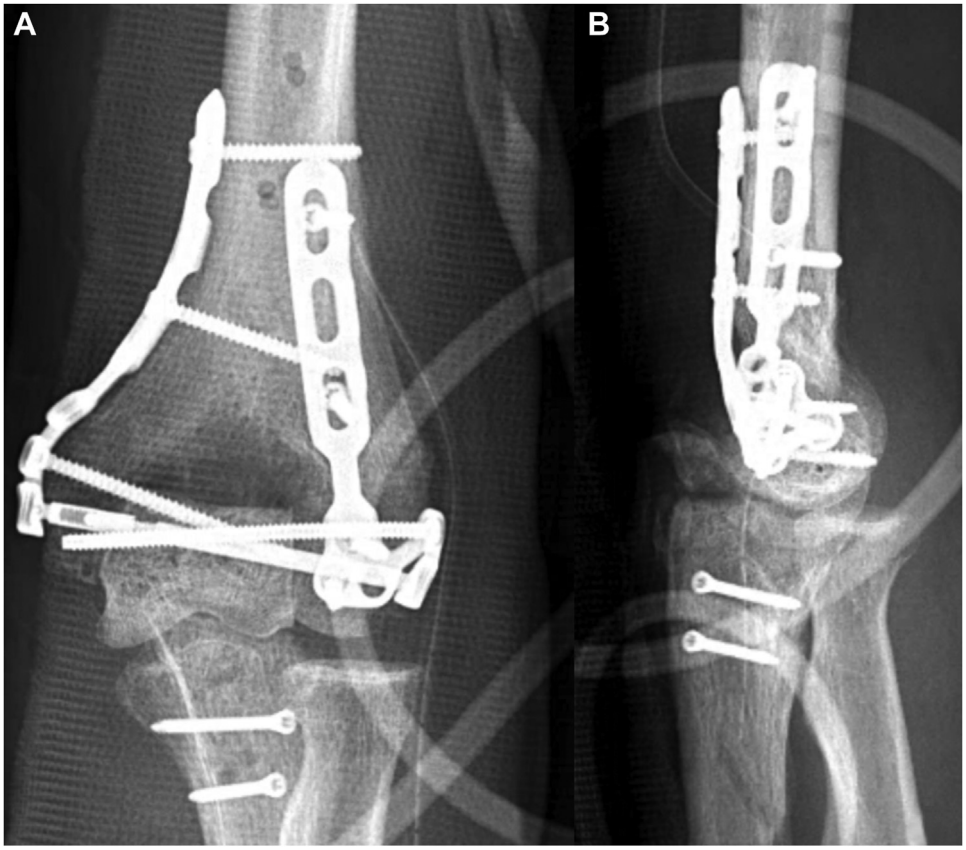

Figure 8 Postoperative (**A**) AP and (**B**) lateral imaging status post allograft fixation. *AP*, anterior-posterior.

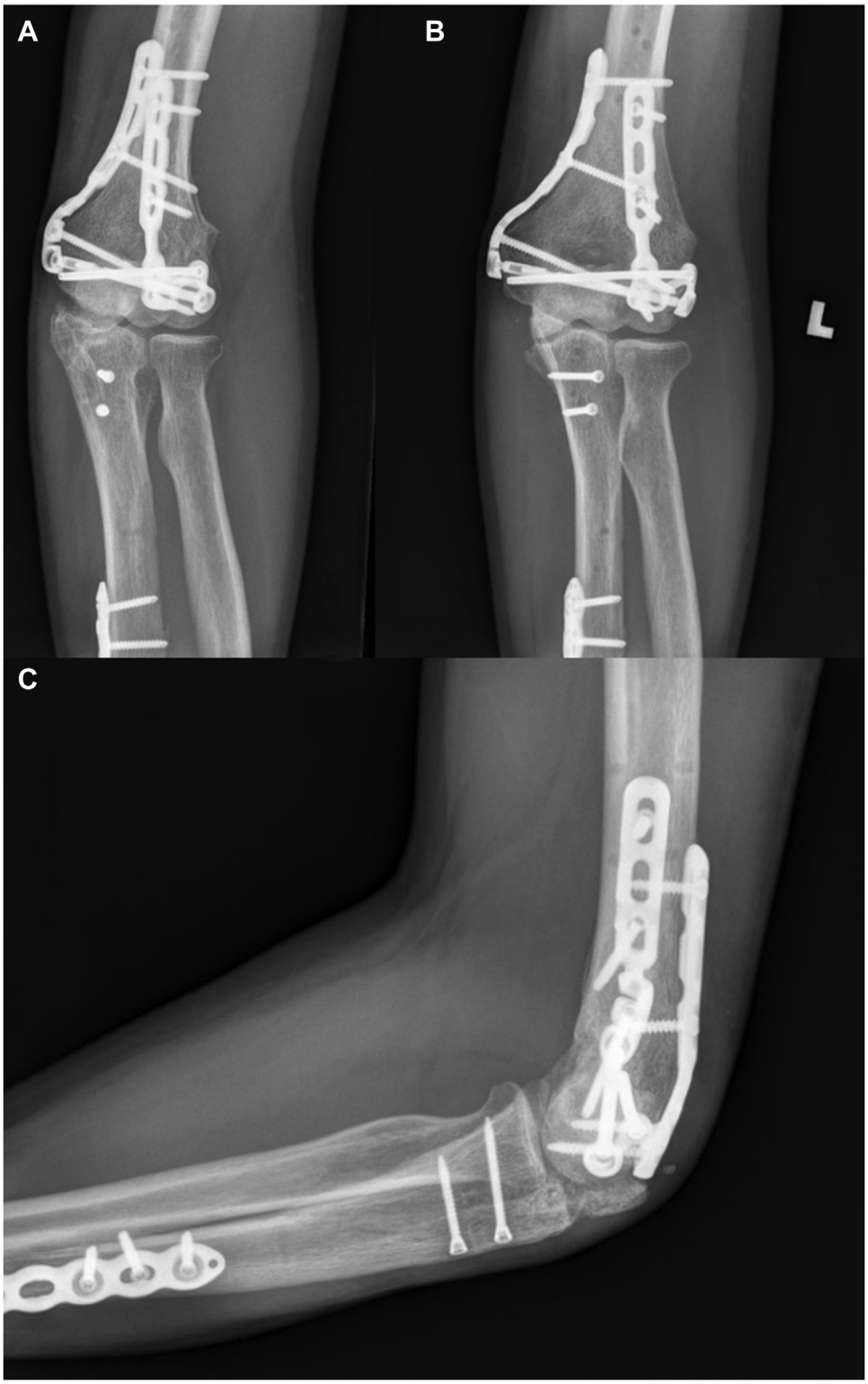

Figure 9 Six-week postoperative (**A**) oblique, (**B**) AP, and (**C**) lateral imaging.

technique report inspires other studies on long-term outcomes using this technique given that this is currently unknown.

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Patient consent: Obtained.

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