CASE CONTROVERSY: INFECTED NONUNION OF THE ULNA

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Case Profile: This 34-year-old patient was involved in a motor vehicle accident with multiple fractures, mainly on the left side, forearm (radius and ulna), acetabulum, and calf.

OPINION: Ilizarov External Fixation and Bone Transport

This 34-year-old patient was involved in a motor vehicle accident and sustained multiple fractures. These fractures involved the left side including the forearm (radius and ulna), acetabulum, and tibia. Each fracture was treated operatively including plating of the radius and ulna, open reduction and internal fixation (ORIF) of the acetabulum, and intramedullary nailing (IMN) of the left tibia. Postoperatively, the ulna developed an acute infection and required early débridement and irrigation and subsequently went on to develop into an infected nonunion (Fig. 1).

Infections and nonunions of the radius or ulnar shafts after ORIF have been estimated to occur between 0% to 5% and 6%, respectively.1,2 Infection eradication does not necessarily depend on implant removal if stable, but implant removal is required in the case of persistent infection. Following eradication of the infection, the previous fracture site had a defect of about 2 cm. At this point, treatment options were evaluated: these included ORIF and morselized bone grafting, ORIF and iliac crest strut graft, or ORIF and free vascularized fibular graft.3–5 Another option included application of an Ilizarov external fixator and bone transport.5–7 To do this, the proximal and distal ulnar fragments were stabilized by thin transfixation pins, and a smooth pin was placed within the medullary canal. The ulna was osteotomized proximally, and the central segment of bone was transported at the rate of 1 mm per day (Fig. 2). An Ilizarov external fixator and bone transport was chosen in order to address the bone defect, minimize the placement of implants within a previously infected bed, and eliminate the need for a bone graft (Figs. 3, 4).

Bone transport using the Ilizarov fixator in the lower extremities to treat bone defects has been well reported.4 Its application in the upper extremities, however, has been limited to case reports.6–8 This method has been applied after a tumor resection in 1 case and after bone defects as a result of injury in 2 other cases. In these cases, maintaining the frame for 10 to 14 weeks was necessary to close 8-cm gaps and to allow bone healing at the docking site. In these cases, complications were mostly pin tract infections and nonunion at the docking site requiring bone grafting.

We had considered other treatment modalities, such as plating and bone grafting or free vascularized grafting, all of which are proven good solutions for nonunions and nonunions with bone defects, but our reservation was that in a case of persistent infection with a possible failure, we would find ourselves beginning the process all over again.

FIGURE 1. Anteroposterior view of the forearm at 4 months after initial trauma. The ulna developed an acute infection with bone loss that needed early débridement and irrigation.

FIGURE 2. Late postoperative radiography taken after initiation of the transport process using a circular external fixator and removing the antibiotic impregnated polymethyl methacrylate (PMMA).
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OPINION: Open Reduction and Internal Fixation and Resection Tricortical Bone Grafting

This case represents a not too uncommon scenario in which open fracture of a long bone, in this case the ulna, goes on to develop into an infected nonunion. The diagnosis of a deep infection and/or osteomyelitis can typically be suspected based upon clinical findings. Important information in making such a diagnosis includes a thorough understanding of the history and nature of the fracture, the patient’s current symptoms, and current physical findings. In the absence of a draining sinus, palpable abscess, or erythema, pain and swelling at the fracture site should raise the surgeon’s suspicions as to the possibility of a deep infection. Routine laboratory studies including a white blood cell count (WBC), erythrocyte sedimentation rate (ESR), and a C-reactive protein (CRP) may assist in the diagnosis, but because of their relatively poor sensitivity are better negative predictors of infection. Although plain radiographs may also assist in the diagnosis, particularly if progressive implant loosening, bone loss, and periosteal reaction are seen, they too are not diagnostic of infection. Other imaging studies including Tc-99 bone scan, Indium nuclear scans, computed tomography (CT), and magnetic resonance imaging (MRI) are only marginally helpful in the face of a previously surgically treated fracture. Of course, definitive diagnosis can be made by obtaining material from the site either via aspiration or biopsy and identifying bacteria within. Once diagnosed, the type of infected nonunion should be classified according to Cierny et al to aid in the treatment and prognosis. According to this classification system, this infected nonunion would be classified as a type IIIA (localized osteomyelitis in a good host).

Initial treatment of infected non-unions with loose or ineffective implants includes debridement of the devitalized and infected material (soft tissues and bone), irrigation, and stabilization. Bone defects can be filled with antibiotic impregnated polymethyl methacrylate (PMMA) to bring high concentrations of antibiotics into the area while maintaining length and space for future reconstruction.

In this case, a thorough debridement of the infected nonunion was performed, leaving a 2-cm ulnar defect, which was temporarily filled with antibiotic impregnated PMMA. A circular external fixator was applied for subsequent bone transport but could have just as easily been stabilized with a 4-pin uniplanar small external fixator. A course of intravenous antibiotics was initiated with the type and duration of antibiotics dependent upon the bacteria isolated, classification of the infected nonunion, and the quality of the host. Confirmation that the infection has been eradicated can be made with some degree of certainty based upon repeat physical examination and laboratory tests (ESR, CRP). A culture negative biopsy of the area, taken after antibiotics have been discontinued at least 5 to 7 days, will add further support that the infection has been eradicated. At this time, definitive reconstruction of the ulna can be performed.

Several options exist for reconstruction of a 2-cm diaphyseal defect in a long bone. These options include bone transport, open reduction and internal fixation (ORIF) with a vascularized bone graft, ORIF with morselized cancellous bone graft, and ORIF with strut graft. Several recent publications have described the successful use of ORIF with strut grafting from the iliac crest for defects of the radius and ulna. The advantages of this procedure over the others include the structural nature of the bone graft, reliable healing of the graft ends, and specialized surgical skills (vascular anastomosis) are not necessary. This technique has evolved over the last 60 years to its current point. The recipient site is prepared by removing the PMMA space, debriding the fibrotic tissue, and freshening the bone ends. Making the ends of the bones blunt aids in the stability and fit of the bone graft. The graft is harvested with an oscillating saw from the anterolateral iliac crest and should be large enough to overfill the defect by approximately 0.5 cm. An oscillating saw is used for precision and to avoid further trauma to the pelvis. The ends of the graft and at the donor site can be left blunt or fashioned as a step-cut. The graft is placed and the ulna stabilized with a 3.5 dynamic compression plate to provide dynamic compression between the ulna and the graft ends. To assure stability, at least 3 plate holes should be available on each side of the bone graft fragment junction and preferably 4 holes. If the graft is longer than 2 to 3 cm, a unicortical screw within the graft can be used to further secure the graft. Residual cancellous bone graft can be packed at each end of the bone graft–ulna junction.
Although this technique has been used successfully in defects of up to 13 cm, defects of 3 cm to 9 cm are most commonly treated in this manner.

Dabezies et al.\(^\text{10}\) used tricortical bone block grafts and plate fixation in 11 patients with defects of 1 or both of the forearm bones. Defects ranged from 1.5 cm to 7.5 cm; healing occurred in 10 of the 11 bones within a period of 9 to 13 weeks. Calkins et al.\(^\text{11}\) used this technique to treat 5 patients with gunshot wounds of the forearm. Healing was achieved in 4 forearms at an average of 6.5 months. Most recently, Barbieri et al.\(^\text{13}\) reported their success with treating 17 patients with diaphyseal defects resulting from infection and bone tissue loss. Average defect length was 5.7 cm, and the grafting was combined with absolute stability using 3.5 mm dynamic compression plates. Healing occurred within an average of 6 months in 14 patients. In each of these reports, failure of the grafting technique was most commonly associated with infection underscoring the need to treat the infections aggressively and to take every precaution to assure eradication of infection before bone grafting.

Bone block strut grafting in the treatment of diaphyseal defects of the radius and ulna provides mechanical support, integrates within a reasonable period of time, restores near normal anatomy, is relatively easy to carry out, and has an acceptably low complication rate.

**REFERENCES**


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**FIGURE 3.** Radiograph taken after frame removal displaying complete union of the ulna and the radius.

**FIGURE 4.** Elbow extension during the last follow-up examination.