All Hope is Not Lost: Saving Limbs with the Orthoplastic Approach

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Introduction

The Penn Orthoplastic Limb Salvage Program provides hope for many individuals who thought they were out of options. Whether they suffered upper or lower extremity mutilating injuries, limb threatening infections, or aggressive bone or soft tissue tumors, the Orthoplastic approach to limb salvage gives patients one last chance at preserving function and a sense of wholeness prior to undergoing amputation. Orthoplastic surgery combines the strengths of orthopaedic and plastic surgery[1] and can be defined as:

"The principles and practices of both specialties applied to clinical problems simultaneously, either by a single provider, or team of providers working in concert for the benefit of the patient."[2,3]

This combined Orthoplastic approach to severe injuries of the extremities provides us as individual surgeons with an expanded view of what is possible in terms of limb salvage and can greatly benefit patients who are on the brink of limb loss.

This article reflects on a few memorable cases of Orthoplastic limb salvage over the last year during our time as hand, micro, and orthoplastic surgery fellows at Penn. No Institutional Review Board approval is necessary at this institution for case series involving 3 or fewer patients. Written, informed consent was obtained from each patient prior to surgery.

Case 1

A 55-year-old female was involved in a motor vehicle rollover after being struck by a semi-truck. Among her injuries was an open both bone forearm fracture with significant bone loss of the distal radius and ulna (Figure 1A). She was initially treated at an outside hospital with irrigation, debridement, and external fixator placement. She was then transferred to Penn for definitive treatment of her fractures and upper extremity orthoplastic limb salvage. The patient was taken to the OR with the orthoplastic team for reconstruction of the 8 cm bone defect in the distal radius with an osteocutaneous free

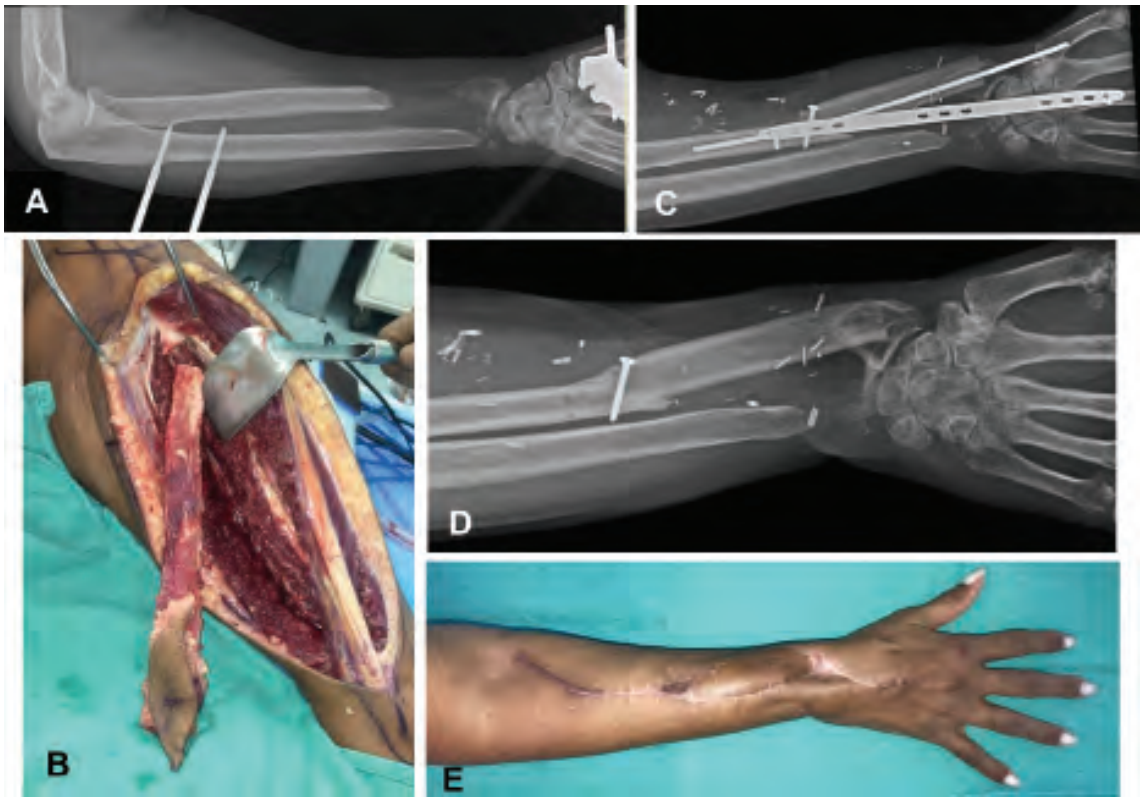

Figure 1. Case 1, Orthoplastic reconstruction of the forearm after an open both bone forearm fracture with an 8 cm defect of the radius **(A)**. This was reconstructed with an osteocutaneous fibula free flap **(B)** and **(C)**. Postoperative radiograph at 7 months showing bone union and a preserved radiocarpal joint **(D)**. Post operative photograph at 5 months **(E)**.

fibula flap (Figure 1B). Upon exploration of her volar ulnar laceration from her open fracture, the ulnar artery was noted to be tied off so the proximal ulnar artery was selected as the recipient vessel for the free flap. The flap was raised and transferred to the defect, fixating the fibula with a Steinmann pin, a dorsal bridging plate, and minimal screws to prevent vascular compromise of the bone flap. The fibula was impacted distally into the remnant of the distal radius to preserve the radiocarpal joint (Figure 1C). After the arterial anastomosis, there was poor egress from the veins, so the decision was made to abort the ulnar artery and use the radial artery in an end-to-side fashion as the recipient vessel which perfused the flap robustly. Two veins were then anastomosed. The patient did well post op and had evidence of partial bone union by 2 months, and complete union by 6 months post-operative. Her hardware was removed at 7 months (Figure 1D). Her wrist has remained stable with approximately 30 degrees of flexion and extension (Figure 1E). If her wrist collapses ulnarly in the future, a total wrist arthodesis to the fibula will be performed.

Case 2

A 38-year-old male was involved in a head-on collision motor vehicle accident and suffered severe bilateral lower extremity trauma. On the right leg, he had a Gustilo IIIA open fracture of the tibia with 15 cm of bone loss (Figure 2A). His fractures were treated at an outside hospital which consisted of an external fixator and a large antibiotic spacer for the tibial defect. One month after the accident he was referred to Penn for limb salvage. He was then taken to the operating room for free fibula flap to reconstruction of the tibial defect. Although fractured, the ipsilateral fibula was used because the contralateral fibula also had a fracture and previous ORIF. There was some difficulty raising the fibula flap because of the significant trauma to the area, but the pedicle and proximal bone was well preserved. The fibula was slid down into the bone spacer cavity using the same approach from the fibula harvest. The proximal fibula flap was placed into a slot in the tibia and secured with a Steinmann pin, a small spring plate, and the external fixator was replaced (Figure 2B). The peroneal pedicle of the fibula was anastomosed to the anterior tibial vessels in an end-to-side fashion. The patient did well post-operatively and was taken back to the OR 6 weeks later for placement of a Taylor Spatial Frame (TSF) and arthrodesis of the fibula to the talus (Figure 2C). He was then transitioned to toe touch weight bearing 2 weeks later, and weight bearing as tolerated 4 weeks after that. Once the fibula hypertrophies sufficiently, the TSF will be removed. He has had one pin site infection postoperatively that was treated successfully with IV antibiotics.

Case 3

A 63-year-old right hand dominant diabetic woman presented who 2 years prior fell and fractured her proximal humerus which was treated at an outside hospital with ORIF. She subsequently developed a severe staphylococcal infection that required 8 more surgeries and removal of all hardware and nearly the entire humerus except the distal portion just above the elbow (Figure 3A) resulting in a flail arm (Figure 3B). After living for some time without a humerus and with very poor dominant hand function she presented to the Penn shoulder and elbow clinic and the Orthoplastic clinic for evaluation. She had been infection free for 11 months. After very thorough informed consent, the decision was made to proceed with a combined humerus allograft, hemi-shoulder arthroplasty, and free vascularized fibula onlay reconstruction. A two-team approach was utilized with the shoulder/elbow team preparing the rotator cuff, hemi-arthroplasty, and humerus allograft, and the orthoplastic team preparing the recipient bed and raising the free fibula flap (Figures 3C-3E). Once the recipient bed and implant were prepared, the allograft was plated to the distal humerus remnant, and sutured in proximally to the rotator cuff. The free fibula was placed into a channel created in the allograft with a bur, and secured with 2 screws (Figures 3F). An end-to-side arterial anastomosis was performed to the brachial artery followed by 2 vein anastomoses. The skin paddle was inset and the incisions closed (Figures 3G and 3H). Because the patient had a history of PE, she was started on a heparin drip immediately after surgery. Her postoperative course has been complicated by a hematoma that required evacuation and delayed wound healing. At 3 months post-operative, the patient is currently in a skilled rehabilitation center.

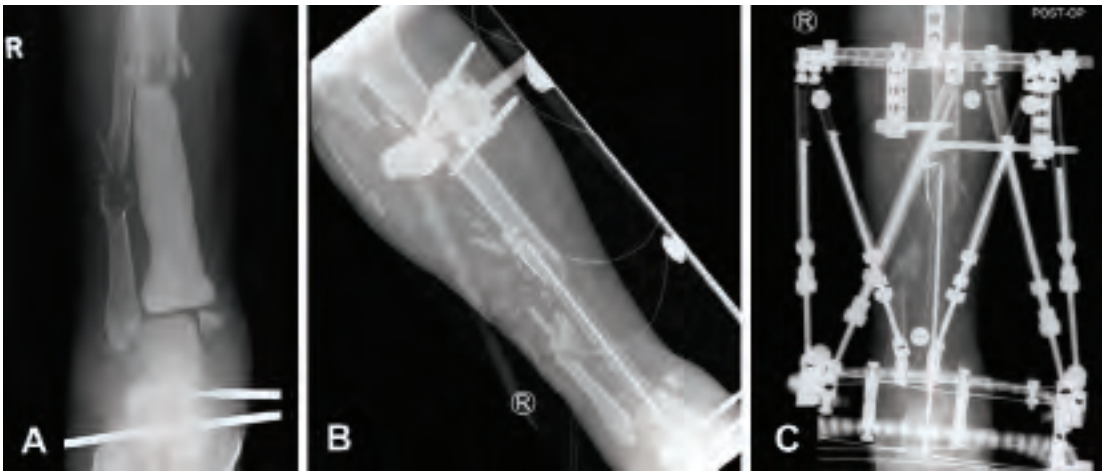

Figure 2. Case 2, Orthoplastic reconstruction of a 15 cm tibial defect after a Gustilo 3A tib/fib fracture **(A)**. Ipsilateral free fibula reconstruction was performed for limb salvage **(B)**. A Taylor Spatial Frame was placed to allow gradual weight bearing and hypertrophy of the free fibula **(C)**.

Discussion

The concept of the Orthoplastic approach brings together the strengths of orthopaedic surgery of stable bone reconstruction and

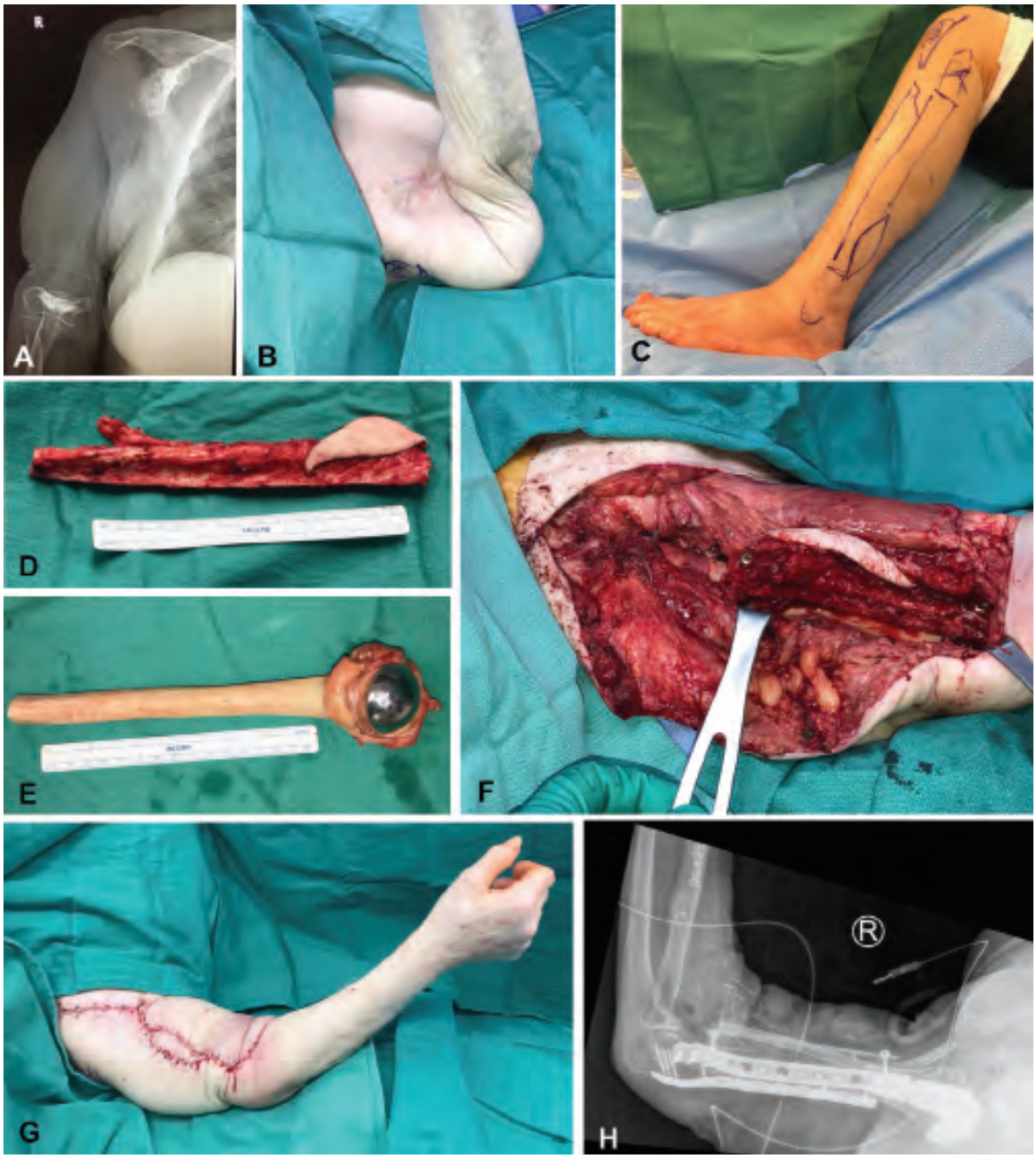

Figure 3. Case 3, Orthoplastic reconstruction of the upper extremity after resection of most of the humerus due to osteomyelitis. Image **(A)** shows an AP radiograph of the arm missing most of the humerus and **(B)** shows a clinical photograph of the flail arm. This was reconstructed with a free fibula osteocutaneous flap **(C)** and **(D)**, combined with a humerus allograft with a hemiarthroplasty **(E)**. Image **(F)** shows the allograft with the fibula onlay after insetting and the immediate post-operative result **(G)** and radiograph **(H)**.

rehabilitation with the microvascular soft tissue and aesthetic principles of plastic surgery simultaneously to maximize outcomes in extremity salvage and reconstruction. When both perspectives are clearly understood and applied, outcomes in reconstruction are maximized. Limb salvage procedures are often demanding but with careful preoperative planning, intraoperative technique, and postoperative care, this approach can lead to successful preservation of the limb and function. Early and late complications can arise, but an experienced microsurgical team can offer complex reconstruction with high rates of success.

References

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