

One-Bone Forearm Reconstruction Procedure as Salvage Operation After Severe Upper Extremity Trauma: A Case Report

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ABSTRACT

An industrial worker in his early 20s sustained a severe injury to the right dominant upper extremity: fracture, inversion, and complete devascularization of the ulna; transection of the median nerve, the radial artery, and almost all flexor tendons of the hand and fingers; loss of all extensor muscles; and transection of the biceps and brachialis muscles at the elbow.

Treatment consisted of conversion to one-bone forearm, immediate reconstruction of the biceps and brachialis muscles and of all flexor tendons of the hand, repair of the radial artery and median nerve and late tendon transfer for extension of the wrist and fingers. Two and a half years after injury, the patient had full flexion and extension of the elbow, full extension but limited flexion of the wrist, and full flexion and extension of the fingers.

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Loss of large sections of the ulna or radius with variable loss of soft tissue presents a significant challenge to the reconstructive surgeon. In 1921, Groves¹ described a patient for whom 2 successive bone-grafting procedures failed to bridge a large radial defect. The problem was solved by transplanting the ulna into the distal fragment of the radius to produce a one-bone forearm. A few years later, Greenwood² and then Watson-Jones³ reported using the Groves procedure for two separate similar cases.

Since then, there have been scattered reports of producing a one-bone forearm for diaphyseal radius or ulna defects resulting from tumor resection, civilian trauma, osteomyelitis, and war injuries.⁴⁻⁶

In this article, we report a complex case of a combined skeletal and soft-tissue traumatic lesion of the forearm. Successful treatment consisted of early conversion to one-bone forearm and late tendon transfers.

The authors have obtained the patient's written informed consent to publish his case report.



Figure 1. (A) Injured arm in emergency department. All extensor muscles were detached from middle segment of ulna and lateral condyle of humerus. Extensor tendons were avulsed from their muscles. Brachialis and biceps muscles were transected. (B) All flexor tendons except flexor profundus of ring finger and flexor profundus of small finger were transected at wrist. Median nerve and radial artery were transected.



Figure 2. Emergency room radiograph shows middle segment of ulna inverted proximal to central.

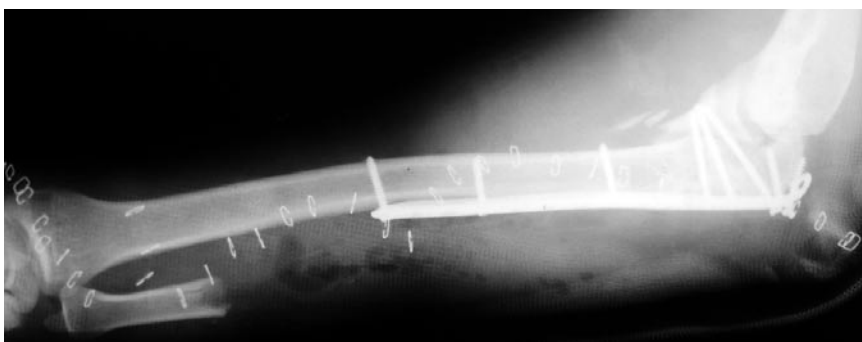


Figure 3. Immediate postoperative radiograph shows fixation of distal radius to proximal ulna. Distal ulna is retained.

CASE REPORT

An industrial laborer in his early 20s caught his arm in a cotton refinery press and sustained a severe injury to the right dominant upper extremity (Figures 1A, 1B). The diagnosis included a type IIIB open forearm

fracture, severe loss of all extensor tendons, and rupture of the biceps and brachialis muscles at the elbow. The inverted ulna segment was completely devitalized because of loss of continuity with the surrounding healthy soft tissues.

ing of the median nerve and anastomosis of the radial artery were performed under loop magnification with microsurgical technique. The transected flexor tendons and brachialis and biceps muscles were thoroughly reconstructed. Muscles and tendons of the dorsal compartment were crushed, and the wound was extremely dirty and contaminated. The severe condition of these tissues made their resection necessary. Wounds were closed primarily after careful débridement and copious irrigation with normal saline. Broad-spectrum intravenous antibiotics were administered for 7 days.

The extremity was protected in a long arm cast for 8 weeks after surgery, until radiographic and clinical evidence of osseous consolidation was present. Progressive range-of-motion and strengthening exercises commenced for the hand and fingers during splinting.

Seven months after initial treatment, tendon transfers were performed to improve hand function and especially finger extension. The stumps of the extensor tendons were dissected at the dorsum of the wrist. The flexor digitorum superficialis of the ring finger was passed to the dorsal compartment and transferred to the stump of the extensor carpi

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fracture with an extended wound to the brachium. Radiographs confirmed a fractured ulna and a dislocated radial head. The ulna fracture had a unique pattern consisting of a large segment (Figure 2) that was totally inverted, central to peripheral and peripheral to central. The patient was transferred to the operating room, where surgical exploration revealed rupture of the radial artery and the median nerve, transection of all flexor tendons except the flexor profundus of the ring finger and the flexor profundus of the small

The one-bone salvage technique was used to restore the stability of the forearm. An osteotomy was performed distal to the radial head, and the proximal ulna was fixed to the stump of the distal radius shaft. Fixation was achieved with plate and screws (Figure 3) and with use of autologous bone graft taken from the radial head. Attention was given to maintaining a neutral position of supination-pronation. For prevention of wrist instability and for cosmetic reasons, the distal stump of the ulna was not resected. End-to-end sutur-

radialis brevis. The flexor digitorum superficialis of the middle finger was transferred to the dorsal compartment and sutured to the stumps of the extensor communis of the index, middle, and ring fingers and to the stump of the extensor digiti minimi. The flexor carpi radialis was transferred to the stump of the extensor pollicis longus. The forearm was protected in a back-slab cast for 5 weeks, and then an intense program of physiotherapy was started.

At the latest (30-month) follow-up, the patient had complete flexion-

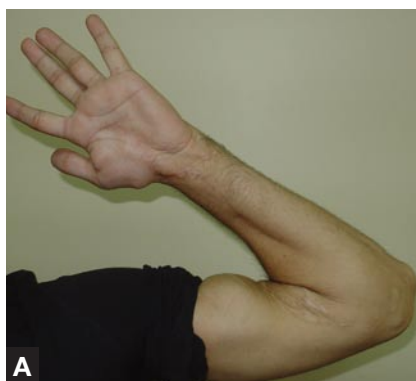


Figure 4. At latest follow-up, patient presented with (A) complete flexion of the elbow and extension of fingers, (B) complete extension of the elbow and flexion of fingers, but (C) limited flexion of wrist.



extension at the elbow, full extension but limited flexion at the wrist, and full flexion and extension at the fingers (Figures 4A–4C). The tenodesis effect was positive. Grip strength was 80 pounds, and tip pinch was 14 pounds. With regard to sensitivity, 2-point discrimination was 15 mm in the thumb, but there was only protective sensation in the index and long fingers. According to the 10-point subjective scoring system described by Peterson and colleagues,⁷ which is based on function, pain, and bone union, our patient's score was 8 points, corresponding to an excellent result. There were no soft-tissue infection, osteomyelitis, hardware failure, or refracture during recovery. The patient returned to his job, but with lighter duties. He expressed complete satisfaction with the outcome of treatment given the severity of his initial injury.

DISCUSSION

In our patient's case, the one-bone forearm reconstructive procedure was selected as a salvage option because of the pattern of the ulna fracture. The

fracture was segmental, and the free middle segment was completely rotated and inverted. The interosseous membrane of the forearm and the annular ligament between the ulna and proximal radius were completely destroyed. The defect was too large and totally devascularized. The surrounding soft tissues were crushed and severely contaminated, and the arterial blood supply of the hand was compromised by the rupture of the radial artery. Resection of the middle fragment of the ulna was inevitable. For these reasons, the option of interposing a vascularized fibular graft was rejected.

The distal part of the ulna was retained and contributed to the fact that no carpal impingement symptoms, instability, or cosmetic deformity was observed. During fixation, the forearm was kept in neutral position, as recommended by the majority of authors.^{2,4,6}

Tendon transfers for extension of the hand and fingers were performed 7 months after injury. By that time, the fracture and soft tissues had healed, and the patient had regained very good function of the flexor tendons of the hand.

To our knowledge, the literature includes few reports on primary construction of one-bone forearm after acute trauma.^{5,7,8} Peterson and colleagues⁷ noted major complications in 10 of 19 patients treated with the one-bone forearm reconstruction procedure. The worst results were found in posttraumatic cases, which had a complication rate of 69% and a mean of 5.6 points on the 10-point grading scale.

Our patient had a stable, pain-free, and functional upper extremity and no complications during recovery. His evaluation score was 8 points on the grading scale used by Peterson and colleagues.⁷ Resection of all avascular, necrotic, and contaminated tissues and stable fixation with protection until union were the principles used to achieve our patient's satisfactory results. Successful tendon transfer contributed significantly to the final outcome.

AUTHORS' DISCLOSURE STATEMENT

The authors report no actual or potential conflict of interest in relation to this article.

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