Triquetral autograft for restoration of the lunate fossa of the distal radius: a case report

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Introduction

Intra-articular fractures of the distal radius are common injuries. They are often the result of high-energy trauma in younger patients or falls in the elderly with osteopenia. While these injuries are difficult to treat, there are a variety of techniques that can be effectively used based on the pattern of fracture. Closed reduction and casting is sufficient for minor injuries, whereas external fixation, open reduction and internal fixation, pinning, bone grafting, or a combination of these techniques is indicated for more severe injuries. If there are bone or soft-tissue defects from open or penetrating injuries, then tissue grafting may also be necessary. Severe difficulties in treatment can be caused by loss of portions of the articular surface of the carpal bones or the distal radius. We present a case of a patient with a gunshot wound that resulted in a distal radius fracture with an unreconstructable lunate facet that was treated with a local osteochondral autograft.

Case Report

The patient was a 19-year-old man who sustained a gunshot wound to his left wrist 5 days prior to transfer to our institution from another hospital. At the other hospital, he underwent irrigation and debridement of the wound and carpal tunnel release through a volar incision. Radiographic

exam on presentation demonstrated a severely comminuted intra-articular fracture of the distal radius with involvement of the lunate facet and near complete absence of the scaphoid (Fig. 1). Physical examination demonstrated decreased sensation in the distribution of the median nerve with weakness of the thenar muscles.

At our institution, the patient first underwent repeat irrigation and debridement as well as exploration of the wound through the previous volar incision. There were partial lacerations of the flexor digitorum superficialis and profundus tendons of the second digit. The median nerve was 90% transected with significant nerve contusion. A dorsal incision was made and an exposure through the third dorsal compartment was performed to visualize the radius and carpus. The residual fragments of the distal radius were stabilized with open reduction and internal fixation. The ulnar corner of the radius was stabilized with two 2.4-mm screws. A large osteochondral defect of the distal radius at the lunate facet remained after fixation. An external fixator was placed across the wrist from the second metacarpal distally to the radial shaft proximally to stabilize the carpus. A computed tomography (CT) scan was obtained the next day to better visualize the carpal and distal radial fractures. This demonstrated the distal radius articular surface defect, proximal pole scaphoid comminution, a comminuted capitate head fracture, a hamate fracture, and a lunate body fracture.

Four days later, the patient returned to the operating room and underwent limited carpal fusion and osteochondral bone grafting of the distal radius. The previous dorsal incision was opened and the comminuted fragments of the capitate were removed and stripped of cartilage. The remaining scaphoid was then excised. The distal aspect of the triquetral articular surface, with a 4-mm-thick portion of underlying bone, was removed using an oscillating saw.

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Fig. 1 Plain anteroposterior (a) and lateral (b) X-rays of the left wrist at presentation showed comminution and partial absence of the scaphoid, a capitate head fracture, and an intra-articular fracture of the distal radius with bone loss at the lunate facet. CT scan (c) demonstrating a large defect in the lunate facet and severe dorsal comminution of the distal radius

The triquetral graft was then fashioned to fit the defect in the distal radius. It was fixed in place with two 2.0-mm screws. The resulting articular surface of the distal radius was found to be well aligned and the lunate was found to articulate well with the osteochondral graft (Fig. 2). The remainder of the cancellous bone graft was packed behind the distal radius for support. The remaining triquetrum, lunate, capitate, and hamate were then denuded of all remaining cartilage and fixed together for an intercarpal fusion. These carpal bones were first provisionally pinned together and then secured with headless two 3.0-mm screws and small-headed screws. The debrided cancellous bone was then mixed with 1.0 cm³ of Grafton Demineralized Bone Matrix Putty (Osteotech, Eatontown, NJ, USA) and was placed in the interstices and impacted down. The capsule was closed with non-absorbable sutures followed by a standard wound closure.

The patient was brought back to the operating room 3 days later for repair of the volar soft-tissue injuries. He underwent repair of the partial laceration to the flexor digitorum profundus and superficialis tendons of the index finger, median nerve grafting, and a split-thickness skin graft from the left thigh to the left wrist. The patient was placed on

antibiotic prophylaxis with cefazolin and his postoperative course was uneventful. The patient was discharged 3 days after the last surgery. He returned to the outpatient clinic 2 weeks later for removal of sutures and to begin protected wrist, finger, and elbow range of motion. At 16 weeks postoperatively, there was radiographic union of the four-corner fusion and the triquetral graft to the distal radius. At final follow-up 9 months postoperatively, the patient had minimal pain and was performing his activities of daily living without problems. Wrist range of motion was flexion of 25° and extension of 30°, with full pronation to 80° and supination to 30°. Median nerve sensation was subjectively improving but he still had thenar atrophy. Direct neurological exam showed two-point discrimination in the ulnar distribution at 5 and 10 mm in the median nerve distribution. Radiographic exam showed a well-healed four-corner fusion mass, good carpal alignment with mild joint narrowing (Fig. 3).

Discussion

Distal radius fractures remain difficult to treat despite their prevalence. This is due in large part to the complex nature

Fig. 2 a, b Images showing triquetral autograft inserted and then fixed into defect in distal radius articular surface

Fig. 3 a–c At 9 months follow-up, complete radiographic union of the four-corner arthrodesis and the triquetrum graft to the distal radius are demonstrated. The carpal fusion mass is reduced on the radius, and the radiocarpal articular surface is maintained

of these fractures and their inability to be treated by a single generic approach. The outcome of the treatment of distal radius fractures is believed to be contingent on certain structural variables such as radial tilt, angulation, and length. However, it has been shown that articular congruity is a major determinant of a successful outcome [12]. Knirk and Jupiter [11] found that 91% of fractures healing with residual incongruity resulted in arthritis. In addition, Trumble et al. [22] found that improvement of articular step-off, gap between fragments, and radial shortening correlated with a more favorable outcome; however, correction of radial tilt or dorsal tilt did not. Although there is disagreement on the contribution of each variable, the importance of restoring the articular congruity of the distal radius is clear.

In severely comminuted fractures, the treatment of intra-articular fractures of the distal radius is challenging. While open reduction and internal fixation alone may be impossible for severely comminuted fractures [10], external fixation may provide reasonable results with these complex fractures [9]. Ruch et al. [17] found plating of the volar lunate facet to be a useful adjunct to external fixation in treating intra-articular fractures, emphasizing the importance of the lunate facet. The prevalence of fractures involving the lunate fossa has been reported in up to 45% of all intra-articular fractures of the distal radius [3]. If the lunate facet is severely damaged, absent, or unreconstructable, then an alternative to an acute wrist fusion would be desirable.

Osteochondral grafting can provide the restoration of the articular surface necessary to achieve functional range of motion at a joint. Osteochondral grafting has been extensively studied with the reconstruction of knee and has demonstrated significant pain relief [5, 14, 15]. Boulas et al. [1] successfully employed the use of osteochondral

metatarsophalangeal autografts to repair articular defects of the metacarpophalangeal joints. In four out of the five cases, radiographs showed articular step-off of 1 mm or less, thus minimizing the risk of osteoarthritis.

Hastings and colleagues [2] (54th Annual Meeting of the American Society for Surgery of the Hand) first presented the hemicondylar hamate replacement arthroplasty. In this procedure, a dorsal portion of the ipsilateral hamate is excised and used to repair defects in the articular base of the middle phalanx as treatment for fracture–dislocations of the proximal interphalangeal joint [24]. Salon and Hemon [18] described two cases in which resected carpal bones were used to restore the articular surfaces of the capitate and distal radius. In the first case, damage to the head of the capitate deterred proximal row carpectomy. Instead, the lunate was excised and the proximal scaphoid was shifted medially and a four-corner fusion was performed. In the second, a damaged lunate fossa was restored using the entire triquetrum as a graft after performing a proximal row carpectomy. The reconstructions remained stable at follow-up at 3 and 6 years. This case is similar to our report, but in our patient, the majority of the triquetrum was left intact in order to perform a four-corner arthrodesis.

Merrell et al. [13] described a case where the sigmoid notch was successfully reconstructed using the scaphoid facet following a severely comminuted intra-articular distal radius fracture. The severe comminution of the remaining distal radius required a radiocarpal fusion, but the distal radioulnar joint was rendered stable. Patterson et al. [16] found that the lunate and triquetrum were similar in several dimensions, especially with regards to maximum length. The volume, maximum length, and surface area of the lunate were found to be 1,663.04 mm³, 21.50 mm, and 830.59 mm², respectively. The volume, maximum length, and surface area of the triquetrum were found to be

1,302.04 mm³, 20.17 mm, and 737.56 mm², respectively. The similarities between the two bones support the use of the triquetral autograft to replace the lunate. Biomechanical studies have found the lunate receives between 31% and 47% of the load in an intact wrist [6–8, 19–21, 23]. In the neutral wrist position, force transmission was found to be greater through the scaphoid fossa than that through the lunate fossa. However, during daily activities such as holding objects and manipulation, the lunate bears more load than the scaphoid [4].

The unique pattern of injury in this case report presented the surgeon with a complex surgical problem. The similarity of the articular surface of the triquetrum to that of the lunate fossa of the radius along with its availability and accessibility enabled the procedure to be performed. The early radiographic results of this reconstruction are promising. This case report illustrates an expansion of the concept of osteochondral grafting to treat comminuted, intra-articular distal radius fractures.

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