Case Report

Side-to-Side Metacarpal Fusion for Reconstruction of Bone Loss in the Radial Carpometacarpal Joints

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A R T I C L E   I N F O

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We present a unique case of side-to-side metacarpal fusion for reconstruction after an isolated gunshot wound to the right hand of a 19-year-old woman. There was a traumatic segmental loss of the proximal right second metacarpal base with considerable comminution of the trapezium and trapezoid. Reconstruction options were limited because of the destruction of the distal carpus and carpometacarpal (CMC) joint. Digital ray amputation was offered but deferred because of patient preference. The reconstruction was performed via metacarpal fusion of the second metacarpal remnant to the third metacarpal base, bypassing the previously destroyed second CMC joint. The fusion of the second and third metacarpals offers acceptable results when the radial CMC joints are traumatized with extensive bone loss.

Reconstruction of unstable fractures involving articular surfaces often requires reducing and fixing non-comminuted fragments. For comminuted fragments not amenable to instrumentation, external fixation can facilitate ligamentotaxis, prevent progressive displacement of fracture fragments, and maintain articular congruity until bony union.1–3 Digital ray amputation may be considered in complex intra-articular fractures with considerable adjacent extra-articular bone loss where fusion is unacceptable or expected to result in inferior hand function.4 Patients may choose ray amputation over salvage for a more rapid return to work or secondary to a desire to avoid multiple procedures with unpredictable outcomes. Ray amputation, however, may result in decreased grip strength and considerable psychosocial stress to the patient.4 We present side-to-side metacarpal fusion as a unique reconstructive treatment option for open fractures and bony loss of the second metacarpal base and CMC joint.

Case Report

A 19-year-old right-hand-dominant woman with no past medical history presented to the emergency department after she sustained isolated gunshot wounds to the dorsum of the fourth webspace and radial wrist. Her hand was well-perfused, and she reported generalized numbness throughout her digits. Imaging revealed comminution of the right trapezium and trapezoid; comminuted intra-articular second and third metacarpal base fractures; and comminuted distal fourth metacarpal shaft and head fractures (Fig. 1). The patient was taken to the operating room for stabilization of fractures. The remaining fragments of the floating trapezium and trapezoid were debrided because of marked comminution. The second metacarpal shaft was reduced with a single lag screw, and segmental loss of the metacarpal base was noted. The second metacarpal remnant was externally fixated in anatomical alignment to maintain length, and the thumb was suspended with a single 0.062 K-wire analogous to a hematoma arthroplasty. The third metacarpal base fracture was fixated with 2 crossing percutaneous 0.035 K-wires driven through the metacarpal neck. The ring finger metacarpal shaft was reduced with 3 transverse percutaneous 0.035 K-wires and externally fixated across the ring metacarpalphalangeal (MCP) joint because of intra-articular fracture involvement (Fig. 2).

Serial postoperative follow-up was performed, and active range of motion (ROM) was noted to be less than 5° in the distal interphalangeal, proximal interphalangeal, and MCP joints because of prolonged immobility and noncompliance with hand therapy. Sensation in the digits returned after 3 weeks. The patient was taken back to the operating room 6 weeks after initial

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injury for definitive treatment of the index finger with open reduction and internal fixation with an interposition autologous iliac crest bone graft. A corticocancellous strut was used to bridge the second metacarpal shaft to the third metacarpal base. We burred a window in the radial cortex of the third metacarpal to expose the cancellous bone and facilitate fusion. The second metacarpal remnant was fixated through the bone graft to the third metacarpal base using a locking plate (Fig. 3). The complex intra-articular fracture of the ring finger metacarpal head was also reduced and fixated with a locking plate. There was radiological evidence of interval healing by 12 weeks.

At her 9-month postoperative follow-up appointment, she was satisfied, reported total resolution of pain, and had improved active ROM. Active ROM was 20° and 15° at the MCP joint of the index and middle fingers, respectively; 45° and 30° at the proximal interphalangeal joints; and 20° at the distal interphalangeal joints (Fig. 4). There was radiologic evidence of
bony fusion with no signs of subsidence or digital shortening (Fig. 5).

Discussion

This patient presented with a unique problem of segmental bone loss of the radial CMC joints. The injury pattern precluded the use of many traditional reconstructive options. Primary bone healing was not possible given the extensive bone loss and intra-articular destruction. Attempts at an anatomic arthrodesis would be technically demanding or impossible given the size of the defect of the proximal second metacarpal and the destruction of the trapezium and trapezoid. Furthermore, because of the mid-carpal joint involvement, a limited carpometacarpal arthrodesis would span the proximal and distal carpal rows and thus be expected to disrupt normal wrist biomechanics and result in future instability and pain. Digital ray amputation can improve hand function and cosmesis through gap elimination and resolution of persistent pain when compared with proximal phalangeal level amputations. However, it is difficult for patients to agree to amputation in the setting of an otherwise normal digit with intact sensation. Given these considerations, we elected for metacarpal fusion to the third metacarpal with autologous bone graft.

To our knowledge, there have been no reports of metacarpal fusion of the second metacarpal to the third metacarpal to treat bony loss of the radial CMC joints. Range of motion increases ulnarily across CMC joints, with the second and third CMC joint offering little to no radial-ulnar deviation and minimal pronation-supination motion compared to the fourth and fifth CMC joint. From previous CMC joint kinematic studies by El-Shennawy et al. the second and third CMC joints, and the fourth and fifth CMC joints are biomechanically similar with respect to joint mobility. As such, we expect that a metacarpal fusion between the second and third metacarpal would not cause major functional impairment. Alternatively, subsidence associated with the collapse of the digital ray would lead to an inevitable extensor lag and major functional impairment. Furthermore, this may impinge on the thumb movement in this patient who underwent simultaneous hematoma arthroplasty of the trapeziometacarpal joint.

Metacarpal fusion has been performed sparingly in the literature in cases with similar defect sizes and patterns. Although rare, this is most commonly seen in the setting of large en-bloc oncologic resections of the metacarpal(s). Hein et al. described a 2-case series describing the reconstruction of the first metacarpal and trapezium after chondrosarcoma and synovial cell sarcoma resection. Autologous bone grafts were used to reconstruct the thumb metacarpal, and the grafts were secured proximally to the second metacarpal shaft via a y-shaped fusion. Both cases resulted in successful arthrodesis with a pain-free thumb. Interphalangeal joint active ROM was 16% of the preoperative motion in the chondrosarcoma reconstruction and 87.5% in the synovial cell sarcoma reconstruction. Similarly, Bergmeister et al. performed a y-shaped metacarpal fusion for reconstruction after complete fifth metacarpal giant cell tumor resection. An iliac crest bone graft was used to reconstruct the fifth metacarpal, and the graft was fused proximally to the fourth metacarpal shaft. At 30 months after surgery, bone union was noted without subsidence and the patient maintained function of the dominant hand.

Finally, Dubert et al. described their 10-year experience with metacarpal fusion for treatment of chronic fifth metacarpal base fracture-dislocation. The authors advocated for resection of the fifth metacarpal base and lateral fusion with bone graft to the fourth metacarpal; this obviates the risk of accelerated arthritis of the triquetrum-hamate joint that may occur in a standard fifth CMC arthrodesis.

We present a case of segmental bone loss of the second metacarpal and second CMC joint secondary to trauma. Metacarpal fusion of the second to the third metacarpal was successful with radiological evidence of union without subsidence or digital shortening. Importantly, our patient was a young, healthy 19-year-old woman without diabetes mellitus, smoking history, or other comorbidities that would increase the risk for postoperative complications; the generalized application of this technique in patients with risk factors for poor bone healing requires further study. Active ROM improved after surgery with consistent hand therapy but never normalized. She reported a DASH score of 56 and is classified as modified independent regarding her normal and instrumental activities of daily living. Bone loss of the metacarpal and articulating carpus with preservation of an otherwise unaffected digit is an injury pattern that can occur after trauma or oncologic resection. Metacarpal fusion is a relatively simple reconstructive option that maintains CMC joint kinematics when the second and third, or fourth and fifth metacarpals are fused. It preserves digital length and avoids subsidence with subsequent extensor lag and major functional impairment. Metacarpal fusion preserves the normal anatomic appearance of the hand, alleviating the psychological burden associated with digital ray amputation.
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Figure 4. Nine-month postoperative photo of the right hand. A Dorsal view of the right hand, active extension. B Volar view of the right hand, active extension. C Volar view of the right hand, active flexion.

Figure 5. Nine-month postoperative x-ray of the right hand of a 19-year-old woman after a gunshot wound to the dorsum of the hand and radial wrist. Radiologic signs of bony fusion without subsidence of digital shortening.