Sigmoid Notch Reconstruction and Limited Carpal Arthrodesis for a Severely Comminuted Distal Radius Malunion: Case Report

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We present the case of a young patient with a severely comminuted, malunited, intra-articular distal radius fracture and complete disruption of the sigmoid notch. We reconstructed the malunited distal radioulnar joint by osteotomy and repositioning the displaced sigmoid notch fragments through a combined dorsal and volar approach. At the same time, we carried out a radioscapholunate arthrodesis with distal scaphoid excision. We used a free vascularized corticoperiosteal flap from the medial femoral condyle to span the massive bone defect in the radius to obtain union. At the 2.5-year follow-up, the patient had essentially normal function of the distal radioulnar joint (painless, with 85° of active pronation and 75° of supination). He resumed work as a bricklayer without limitations. We conclude that sigmoid notch reconstruction by osteotomy is worthwhile in the setting of malunited distal radius whether or not the radiocarpal joint is reconstructable. *(J Hand Surg 2012;37A:481–485. Copyright © 2012 by the American Society for Surgery of the Hand. All rights reserved.)*

Key words Sigmoid notch, intra-articular osteotomy distal radius, distal radius malunion, distal radioulnar joint.

DORSAL TILT, RADIAL INCLINATION, radial translocation, or shortening of the distal radial fragment may be responsible, alone or in association, for distal radioulnar joint (DRUJ) pathology in malunited distal radius fractures.[1,2] As long as the sigmoid notch anatomy is preserved, procedures exist to reconstruct the DRUJ relationships. Radial osteotomy and ulna shortening with or without ligament reconstruction are among the most common. When the sigmoid fossa is irreversibly damaged, however, the options are limited to a salvage procedure. Darrach, Bower, Sauvé-Kapandji, and ulnar head replacement are the most popular alternatives. None of the salvage operations will provide a normal joint. Residual pain and limitations in grip strength and motion are all too common after salvage operations.[3]

Reconstruction of the sigmoid notch facet after a fracture has rarely been reported. Merrell et al[4] published a case report in which a nonvascularized osteochondral graft was taken from the scaphoid fossa to reconstruct a partial defect of the sigmoid notch. del Piñal et al[5,6] reconstructed not only the dorsal part of the sigmoid notch but also the lunate fossa, by means of a vascularized osteochondral flap taken from the base of the third metatarsal.

When treating intra-articular malunions of the distal radius, it is often necessary to mobilize the medial fragments. This is done to restore the contour of the lunate facet. This indirectly restores the anatomy of the sigmoid notch. However, we have not found a case in which the sigmoid fossa has been specifically reconstructed by mobilizing the malunited fragments. The purpose of this article was to present a complex intra-articular malunion of the radius in which the sigmoid notch was reconstructed with good results.

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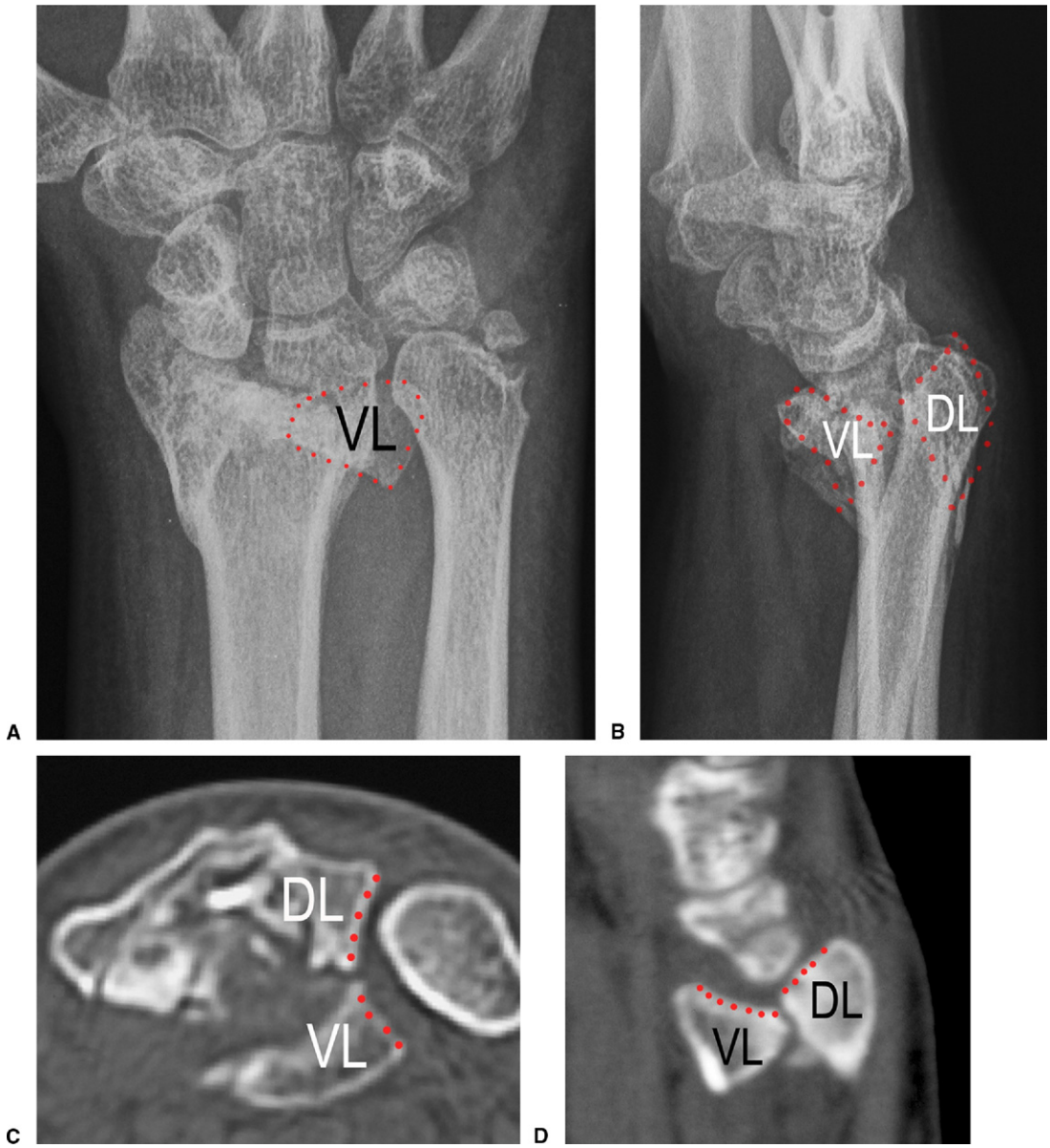

FIGURE 1: A–D Plain x-rays at the first visit (4 months after the injury). On the computed tomography scan 1 month earlier, the 2 fragments that formed the sigmoid notch articular facet (volar-lunate facet fragment [VL] and dorsal-lunate facet fragment [DL]) are highlighted.

CASE REPORT

A 23-year old man sustained a high-energy distal radius fracture and a comminuted scaphoid fracture of the dominant wrist in a motor vehicle accident. Initial treatment consisted of external fixation for the distal radius fracture and percutaneous K-wire fixation of the scaphoid fracture. The wires and external fixator were removed at 8 weeks. Because of persisting pain, a total wrist arthrodesis with a Sauvé-Kapandji procedure was recommended at the patient's local facility. He presented to us for a second opinion.

We first saw the patient 4 months after injury. He reported painful radiocarpal and DRUJ joints. The wrist moved from 20° of flexion to 45° of flexion. Pronation was 30° and supination was 10°. Grip strength was 14 kg, which was 30% of the uninjured side. There was volar displacement of the wrist and prominence of the ulnar head.

On plain radiograph the lunate and scaphoid had sunk more than 1 cm into the radius (Fig. 1A, B). The severity of comminution at the scaphoid and lunate fossae shown by the computed tomography scan was such that we judged it impossible to reconstruct this area by osteotomy and repositioning of the fragments. Consideration was given to the possibility of radioscapholunate arthrodesis with distal scaphoid exci-

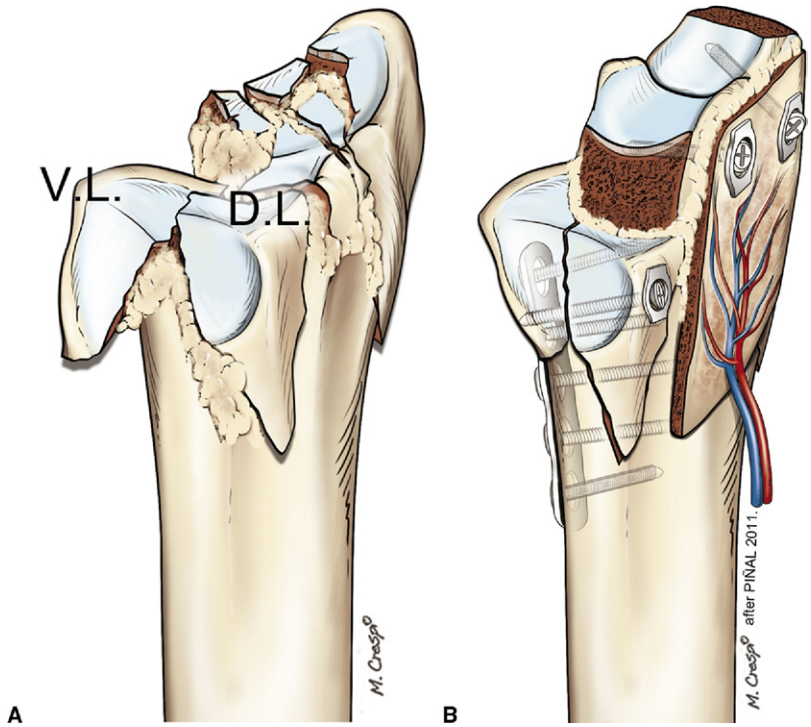

FIGURE 2: **A** Preoperative appearance; **B** reconstructive plan.

sion.[7] Regarding the DRUJ relationships, the ulna was 12 mm long in relation to the radius and the sigmoid notch was disrupted into 2 major incongruent articular fragments: a volar-lunate and a dorsal-lunate fragment (Fig. 1C, D). The 2 fragments appeared to include most of the cartilage of the sigmoid notch and little of the lunate fossa.

We discussed 2 completely different operative plans with the patient, depending on the intraoperative findings. The first was if the sigmoid notch could be reconstructed, and the second was if it could not. In both instances, a radioscapholunate arthrodesis was to be done. However, if the sigmoid notch were to be reconstructed, restoring the radial length would create a massive intercalated defect. We thought a vascularized corticoperiosteal flap would be necessary in this case to ensure union between the radius, the scaphoid, and the lunate (Fig. 2). On the contrary, if we determined that the sigmoid notch was not reconstructible, a Darrach procedure would be done to treat the DRUJ problem. In that case, the radius could be shortened as required to achieve good bone coaptation, which would make the corticoperiosteal flap unnecessary.

Through a midline dorsal incision, we approached the distal radius and carpus. Complete destruction of the cartilage of the radius was confirmed. We performed an osteotomy through the site of the scaphoid fracture and resected the distal portion. The dorsoulnar lunate fossa fragment, which contained the dorsal half of the sig-

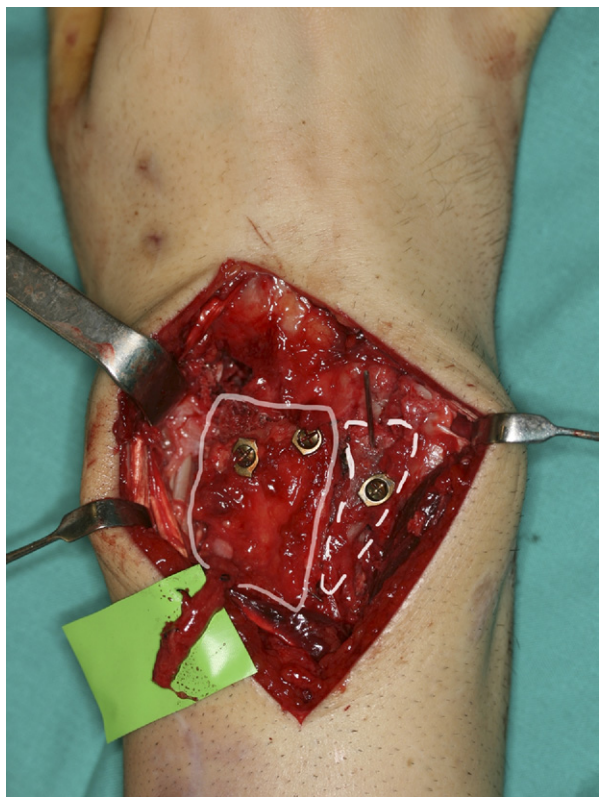

FIGURE 3: Intraoperative view before revascularization. The corticoperiosteal flap and the dorsal-ulnar radius fragment (containing the dorsal part of the sigmoid notch) have been highlighted.

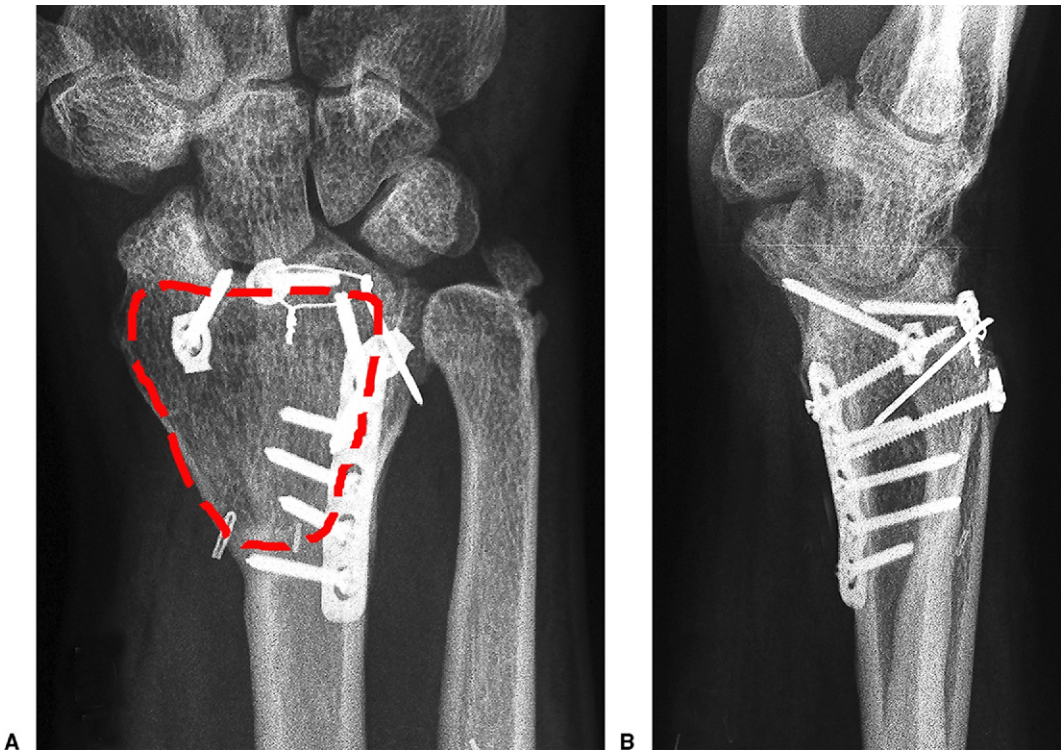

FIGURE 4: A, B Plain x-rays at 2.5 years. The outlines of the corticoperiosteal flap have been marked.

moid notch, was mobilized and swung ulnarly. To avoid late osteonecrosis and graft resorption, we took great care to preserve the soft tissue connections that attached to the sigmoid notch distally and ulnarly. At this stage, we could see that the ulnar head was covered by healthy cartilage. In the depths of the wound, we identified the volar half of the sigmoid fossa cartilage and judged it to be acceptable.

Through a volar-ulnar incision, the space between the ulnar neurovascular bundle and the flexor tendons was developed and the distal part of the pronator quadratus was reflected proximally, giving access to the volar-ulnar corner of the radius. We released the volar-lunate fragment from surrounding scar except for its distal and ulnar soft tissue connections, to keep its blood supply intact. We separated this fragment with a fine osteotome and repositioned it using the metaphysis as the reference. It was fixed with a 2.0-mm AO plate applied to the volar-ulnar aspect of the radius. Then, through the dorsal approach, the dorsal-ulnar fragment was reduced to the volar-ulnar fragment, thus restoring the sigmoid notch facet anatomy. We used a 2.0-mm lag screw with a washer to fix this fragment to the volar counterpart.

As expected, a considerable osseous defect was present between the healthy radius and the lunate and proximal portion of the scaphoid once we restored the length of the radius and resected the scarred bone and cartilage of the proximal aspects of the carpals. We harvested a vascularized corticoperiosteal flap[8] from the medial femoral condyle.[9] A thin layer of cancellous bone was included in the periphery of the flap, progressing up to 1 cm thick at its center. We harvested the flap to include a larger piece of vascularized bone, to later match the larger central defect in the arthrodesis area. We also harvested cancellous bone graft from the medial femoral condyle. We noticed profuse oozing from all flap surfaces once the tourniquet was released from the leg. We then divided the vessels and transferred the flap to the hand.

Although flap harvesting was quick in this thin patient (25 minutes), the carpentry to fit the flap at the wrist was painstaking and took 75 minutes. We created a rectangle of the appropriate shape and depth on the dorsum of the lunate, scaphoid, and distal radius to match the dimensions of the harvested flap. To maintain the scapholunate relationships in the midcarpal joint, we prepared only the proximal half of this joint for arthrodesis. The intact dorsal scapholunate ligament was left undisturbed for the same reason. We packed cancellous bone volarly between the radius and carpus. Then, while an assistant distracted the wrist slightly, we press-fit the corticoperiosteal flap into the tailor-made rectangle, spanning the dorsal radius, scaphoid, and lunate. With a thin impactor, taking utmost care not to damage the vessels on the flap surface, we further

stabilized the flap. A 2-mm lag screw to the lunate and another to the proximal scaphoid was all the fixation required, because the construct was tightly fit in the radius itself (Fig. 3). The dorsal-ulnar fragment was further apposed to the corticoperiosteal flap by a tension wire between a temporary K-wire and the screw in the lunate. We filled any bone gap with cancellous bone graft and carried out revascularization on a branch of the posterior interosseous artery and a subcutaneous vein. We noticed bleeding from the flap immediately after the tourniquet was released. The wounds were closed without drainage. The whole operation took 3 hours 45 minutes and was carried out under combined axillary and spinal blocks. The postoperative course was uneventful, and the patient was discharged 4 days after the operation on full weight bearing and was recommended to rest with the leg elevated. Subcutaneous heparin was maintained for 3 weeks, the time it took him to resume most ambulatory activities. The wrist was immobilized for 4 weeks in a volar splint, allowing free pronation-supination because the fixation at the sigmoid notch was sufficiently stable. At that time, a removable splint was used for another 4 weeks. We recommended active and active assisted flexion, extension, and pronation-supination exercises several times a day. The patient decided to pursue self-directed rehabilitation and moved to his hometown.

The patient was recalled for the purpose of this study 2.5 years after the operation. He had no pain and was working as a bricklayer without limitations. He has 20° extension, 30° flexion, 85° pronation, and 75° supination (corresponding to 89% of the pronation-supination arc of the contralateral side). Grip strength was 46 kg (96% of the healthy side) Plain x-rays showed well-preserved spaces at the DRUJ and at the midcarpal level without signs of degeneration in either joint (Fig. 4).

DISCUSSION

Ulnar pain, loss of pronation-supination, and DRUJ instability are frequent in the setting of malunited distal radius fracture. However, many of the ulnar problems may be corrected by a radius osteotomy because the sigmoid notch will be repositioned and the anatomic relationships of the DRUJ restored. When there is incongruency at the sigmoid fossa, some form of salvage operation (Darrach, Bower, Sauvé-Kapandji, or prosthesis) is recommended, but the DRUJ is never normal.[3]

The sigmoid notch articular seat is small. After studying 50 cadavers, Tolat et al[10] found it to be 8 mm (proximal to distal) by 19 mm (posterior to anterior). However, it is well known that minimal variations in its shape may be responsible for major side effects. Tham and Bain[11] treated recurrent subluxation of the ulna by slightly modifying its shape (sigmoid notchosteoplasty). Merrell et al[4] and del Piñal et al[5,6] reconstructed major articular defects by osteochondral grafts.

This case demonstrates that it is reasonable to reconstruct the sigmoid notch by osteotomy in selected cases of malunion of the distal radius that includes malunion of the notch.

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