Chapter 13
1,2 ICSRA for the Management of Proximal Pole Scaphoid Nonunion

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Case Presentation

A 24-year-old woman injured her right wrist in a car accident 6 months prior to presentation. She did not initially seek medical attention for the wrist injury. However, she had persistent right wrist pain, and subsequently sought medical attention 6 months after the initial injury. Her pain was worse with grip and exertion, but she was otherwise able to use her wrist for other activities of daily living. Her past medical history was unremarkable.

Physical Assessment

Musculoskeletal examination revealed relatively well-preserved wrist motion, with wrist extension of 70° and flexion of 100° on the right, as opposed to wrist extension of 85° on the right and

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flexion of 105° on the left (normal) side. Ulnar deviation was 55° on the right and radial deviation was 20° on the right, as opposed to ulnar deviation of 60° and radial deviation of 30° on the left side. Grip strength on the right was 36 kg, while that on the left was 30 kg. Appositional pinch was 6.5 kg on the right and 6 kg on the left. On the right wrist, Watson's test was negative and she had point tenderness over the proximal scaphoid which reproduced her daily symptoms of pain.

Diagnostic Studies

Plain radiographs of the right wrist revealed a proximal pole non-union of the scaphoid at the level of the proximal pole, without humpback deformity. This was confirmed on CT of the right wrist (Fig. 13.1) that showed the nonunion with minimal extension of the lunate. An MRI was obtained and was concerning for avascular necrosis (AVN) of the proximal pole.

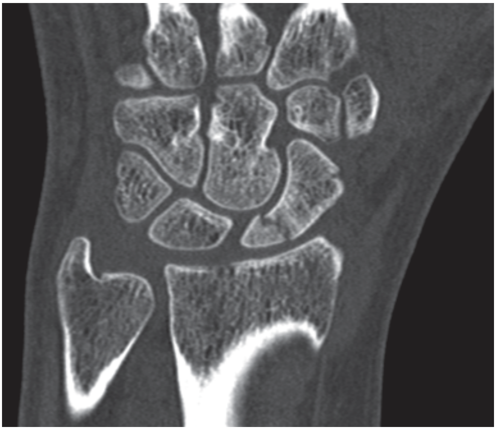

Fig. 13.1 Preoperative CT scan shows nonunion of a scaphoid proximal pole fracture. (Published with kind permission of ©Harvey Chim, David G. Dennison, and Sanjeev Kakar, 2015. All Rights Reserved)

Diagnosis

The patient was diagnosed with a nonunited proximal pole fracture of the right scaphoid.

Management Chosen

Due to the presumed poor vascularity of the proximal pole of the scaphoid, together with the lack of a humpback deformity or lunate extension, she was considered to be a good candidate for a 1,2 intercompartmental supraretinacular artery (ICSRA) vascularized bone graft procedure. The ultimate decision about the vascularity of the proximal pole and the need for a vascularized bone graft, however, would be determined intraoperatively.

Surgical Technique

A curvilinear incision, paralleling the course of the extensor pollicis longus (EPL), was outlined over the dorsal radial border of the wrist. Gravity exsanguination was used as opposed to an Esmarch bandage to permit 1,2 ICSRA vessel identification. The superficial branches of the radial nerve were identified and protected. The 1,2 ICSRA was identified running along the extensor retinaculum between the 1st and 2nd extensor compartments. It arises from the radial artery approximately 5 cm proximal to the radiocarpal joint and passes beneath the brachioradialis to lie on the dorsal surface of the extensor retinaculum. Distally, the vessels anastomose with the radial artery within the anatomical snuffbox. It is off this distal anastomosis that this reverse-flow vascularized bone graft is based.

The transverse proximal limb of a ligament sparing capsulotomy was then made over the radiocarpal joint to expose the proximal pole of the scaphoid. The fracture site was debrided with curettes and small osteotomes to minimize any thermal necrosis that may be caused by a high-speed burr and the tourniquet deflated to examine the vascularity of the proximal pole. There was scant bleeding from the proximal pole and so a decision was made to stabilize the nonunion and augment this with the 1,2 ICSRA-fed autograft. A partially threaded cannulated headless compression screw was then passed from proximal to distal, preferentially placing the screw volarly to allow the graft to be placed dorsally. Osteotomes were then used to make a box cut dorsally around the site of the scaphoid nonunion to create a space for the vascularized bone graft (Fig. 13.2).

Attention was then turned to harvesting the bone graft. The 1,2 ICSRA vessel was identified, and the 1st and 2nd extensor compartments were opened radially and ulnarly, respectively, to leave a cuff of tissue around the pedicle of the graft. The vascularized bone graft was centered approximately 15 mm proximal to the joint line to include the nutrient vessels (Fig. 13.3). To achieve this, the proximal vessels leading to the graft were ligated. The distal pedicle was then raised off the extensor retinaculum with care to preserve their integrity as they supply the outlined graft. The graft was elevated using osteotomes, and care was taken to ensure it was not kinked or rotated as it was transposed distally.

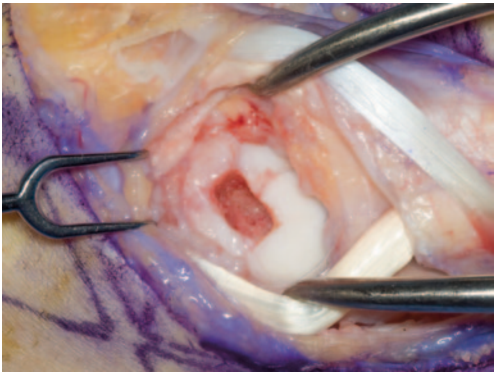

Fig. 13.2 A box cut is made around the fracture site in the scaphoid to create space for the 1,2 ICSRA vascularized bone graft. *ICSRA* intercompartmental supraretinacular artery. (Published with kind permission of ©Harvey Chim, David G. Dennison, and Sanjeev Kakar, 2015. All Rights Reserved.)

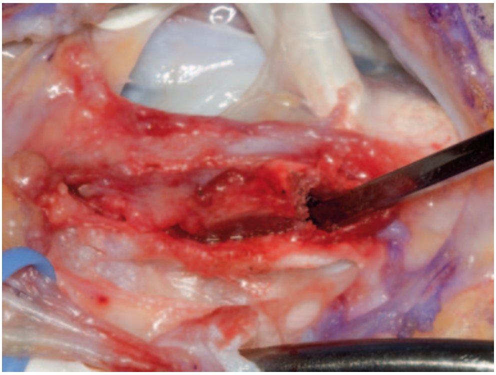

Fig. 13.3 The 1,2 ICSRA vascularized bone graft has been raised and is isolated on its pedicle. *ICSRA* intercompartmental supraretinacular artery. (Published with kind permission of ©Harvey Chim, David G. Dennison, and Sanjeev Kakar, 2015. All Rights Reserved)

A small additional wedge cut parallel to one longitudinal border of the graft can help with completing the deep cancellous cut without breaking the graft. With the tourniquet deflated, one can observe pulsatile bleeding from the bone surface. The pedicle and vascularized bone graft were then transposed distally underneath the second compartment tendons. A small amount of cancellous bone graft from the distal radius donor site was first packed into the defect, and then, the 1,2 ICSRA graft was gently tamped and pushed into place dorsally. The distal radius donor site was then packed with bone allograft and the incision closed in layers. A long-arm thumb spica splint was placed.

Clinical Course and Outcome

The patient was immobilized in a long-arm thumb spica cast for 4 weeks postoperatively and then transferred into a short-arm thumb spica cast until union. Given the difficulty associated with determination of osseous union with plain radiographs, and the prolonged average time to union with proximal pole fractures

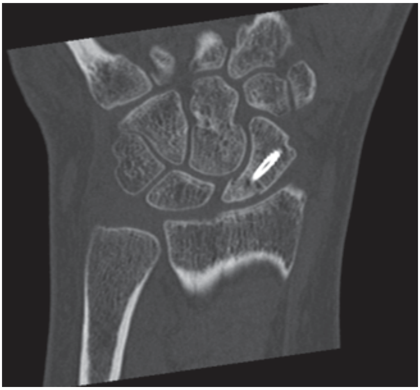

Fig. 13.4 Three-month postoperative CT scan shows union across the scaphoid proximal pole nonunion site. (Published with kind permission of ©Harvey Chim, David G. Dennison, and Sanjeev Kakar, 2015. All Rights Reserved)

[1–4], a CT scan is obtained at 12 weeks. This showed healing across the fracture site (Fig. 13.4). The patient was then placed into a thumb spica splint and gradually weaned out of this as she advanced her range of motion and strengthening exercises. At 1-year follow-up (Fig. 13.5), she had regained 75 % and 86 % of wrist extension and flexion compared to the contralateral side. Ulnar and radial deviation, as well as grip strength, were symmetrical.

Clinical Pearls/Pitfalls

- The 1,2 ICSRA pedicle should be identified prior to incising the extensor retinaculum.
- It is indicated in scaphoid proximal pole avascular nonunions without evidence of humpback deformity.
- A volarly based screw in the scaphoid allows stable fixation of the scaphoid, while allowing space for placement of the dorsal 1,2 ICSRA vascularized bone graft.

Fig. 13.5 Radiograph at 1-year postreconstruction showing union of the fractured proximal pole. (Published with kind permission of ©Harvey Chim, David G. Dennison, and Sanjeev Kakar, 2015. All Rights Reserved)

- In the presence of AVN of the proximal pole with carpal collapse, a free vascularized bone graft such as a medial femoral condyle or rib autograft may be considered as an option for treatment of the nonunited scaphoid fracture.

Literature Review and Discussion

Within the carpus, the scaphoid is the most commonly fractured, and accounts for more than 60 % of all carpal bone fractures [5]. Nonunion is a problem that is encountered particularly often with scaphoid fractures, especially in those involving the proximal one third of the scaphoid. This relates to the blood supply of the scaphoid, which is primarily derived from branches from the radial artery entering the scaphoid through foramina on its distal dorsal ridge. The vascular supply of the proximal pole hence is derived in a retrograde fashion from these vessels proceeding from distal to proximal, and is easily disrupted following a fracture. With disruption of the blood supply of the proximal pole, AVN develops in approximately 3 % of all scaphoid fractures [1]. When a scaphoid nonunion is left untreated, a predictable pattern of degenerative arthritis develops, termed scaphoid nonunion advanced collapse (SNAC), progressing from localized to pancarpal arthritis.

Various techniques have been attempted for treatment of scaphoid nonunion of the proximal pole, such as nonvascularized autografts from the iliac crest or internal fixation with a screw alone. However, these techniques have had limited success, due to the poor vascularity of the proximal scaphoid pole. Vascularized pedicled bone grafts are useful in the treatment of scaphoid nonunion, and were initially reported by Zaidemberg et al. [6] for the treatment of long-standing scaphoid nonunions. Most commonly, these are based off vessels supplying the dorsal distal radius, arising from the radial artery and running in a retrograde fashion. Two consistent intercompartmental vessels exist, lying superficial to the extensor retinaculum. These are the 1,2 ICSRA and 2,3 ICSRA. Two other deep vessels arise from the dorsal carpal arch, the 4th and 5th extensor compartment arteries (ECA). The 1,2 ICSRA and 2,3 ICSRA are useful for grafting the scaphoid, while the 4th ECA is more useful for grafting the lunate due to the ulnar location of this vessel.

The 1,2 ICSRA is the most common pedicle used for vascularized bone grafts in scaphoid nonunions. It arises from the radial artery approximately 5 cm proximal to the radiocarpal joint and passes beneath the brachioradialis to lie on the dorsal surface of the extensor retinaculum. Although the pedicle has a short arc of rotation, its radial location makes it ideal for grafts to the scaphoid.

The 1,2 ICSRA vascularized bone graft has been shown to have excellent results, with union in 95 to 100 % of the patients [2, 6–9], in the absence of avascular necrosis (AVN) of the proximal pole. Despite the improvements in MRI technology, the sensitivity and specificity for the diagnosis of AVN have been quoted as 76 and 99 %, respectively, in one study [3]. Given this, the most accurate determination of avascularity is the absence of punctate bleeding noted intraoperatively with the tourniquet deflated [4, 8]. With AVN of the proximal pole, however, the union rate decreases to around 60 % [2, 4, 10]. In a single-center study comparing outcomes with and without AVN, Chang et al. [2] reported that union occurred in 71 % of patients with proximal pole scaphoid nonunion, but only 50 % of patients with nonunion and AVN. Risk factors associated with failure of this vascularized bone graft included preoperative humpback deformity, female gender, older age, avascularity of the proximal pole, nonscrew fixation of the graft, and the use of tobacco.

In the presence of AVN and a humpback deformity (defined as a lateral intrascaphoid angle more than 45 °), a larger structural graft, such as a free medial femoral condyle flap, may be more appropriate to ensure fracture union [11, 12]. Unlike the 1,2 ICSRA vascularized bone graft, which is limited in size, the medial femoral condyle flap has sufficient structural support to correct the humpback deformity and restore carpal geometry. Jones et al. compared the outcomes of 1,2 ICSRA and medial femoral condyle in the management of scaphoid nonunion with carpal collapse and avascularity of the proximal pole [11]. The authors noted that patients treated with the 1,2 ICSRA graft had a 60 % union rate compared to a 100 % union rate (13 of 13 patients) within the medial femoral condyle cohort.

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