Chapter 10
Scaphoid Nonunion Treated with Iliac Crest Structural Autograft

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Case Presentation

A healthy 22-year-old right-hand dominant professional mountain biker sustained a left scaphoid waist fracture after a fall from his mountain bike. He initially presented to an outside hospital where he was treated with cast immobilization for 4 weeks. He went on to develop a scaphoid nonunion that was subsequently treated with open reduction and internal fixation using distal radius bone graft. He presented 2 years after his injury with persistent radial-sided wrist pain limiting his ability to ride his bicycle competitively. There is no relevant past medical history and the patient denied tobacco use.

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Physical Assessment

Physical examination revealed 85° of wrist flexion, 75° of wrist extension, and full supination/pronation. In addition, there was tenderness along the anatomic snuffbox and at the scaphoid tubercle.

Diagnostic Studies

The evaluation of a patient with wrist pain begins with a complete history and physical along with radiographic imaging consisting of a wrist PA, oblique, lateral, and a scaphoid view. Radiographs obtained at the patient's initial visit revealed bone resorption at the fracture site and lucency surrounding the compression screw, findings consistent with a scaphoid nonunion (Fig. 10.1, 10.2). Mild radial styloid beaking was noted on the AP radiograph indicating early stages of a stage I scaphoid nonunion advanced collapse (SNAC) wrist [1]. The lateral radiograph revealed slight extension of the lunate and the presence of a humpback deformity (Fig. 10.2). Although not required, a CT scan of the wrist may provide additional information that can assist in the management of a scaphoid nonunion. It may confirm the presence of a nonunion and help quantify the amount of bone resorption and degree of humpback deformity [2, 3]. A CT scan was obtained which confirmed the absence of bone healing and the presence of a humpback deformity. An MRI without contrast is also frequently obtained to evaluate the vascularity of the proximal pole of the scaphoid [4]. This is particularly important in proximal pole fractures. If there is evidence of avascular necrosis (AVN) of the scaphoid, a vascularized bone grafting procedure is the treatment of choice. An MRI was obtained in this patient but the presence of the scaphoid screw introduced significant metallic artifact preventing adequate assessment of the vascularity of the proximal pole of the scaphoid.

Fig. 10.1 Preoperative AP X-ray demonstrating persistent scaphoid nonunion. (Published with kind permission of © Roberto Diaz and James Chang, 2015. All Rights Reserved)

Management Options

Treatment options discussed with the patient included observation, casting, revision open reduction internal fixation with bone graft, and salvage procedures.

Management Chosen

Given the patient's persistent pain, young age, and only mild beaking of the radial styloid, revision surgical stabilization with autograft was recommended. Although the MRI could not definitively rule out proximal pole AVN due to metallic artifact, our suspicion for AVN of the proximal pole was low as the incidence of AVN is much lower following scaphoid waist fractures [5]. The

Fig. 10.2 Preoperative lateral X-ray. (Published with kind permission of © Roberto Diaz and James Chang, 2015. All Rights Reserved)

patient was consented for hardware removal, open reduction internal fixation with iliac crest bone graft (ICBG) versus vascularized bone graft and radial styloidectomy.

Surgical Technique

Surgery was performed on an outpatient basis under general anesthesia in addition to an infraclavicular regional block for postoperative pain control. The patient was placed in the supine position with a bump under the ipsilateral hip to facilitate ICBG harvesting. A volar approach is preferred when correction of a humpback deformity is required. In this case, the patient's previous volar incision

Fig. 10.3 Intraoperative photograph of the volar approach. (Published with kind permission of © Roberto Diaz and James Chang, 2015. All Rights Reserved)

was used to access the scaphoid and the radial styloid (Fig. 10.3). A radial styloidectomy was performed and previous hardware was removed. The scaphoid fracture was identified and the presence of a nonunion was confirmed. The proximal and distal poles were excavated and all nonviable bone was removed. Bleeding was noted at the proximal pole and therefore, a vascularized bone graft was deemed unnecessary. Scaphoid length and alignment were obtained using a small lamina spreader and Kirschner wires (K-wires) as joysticks. A guidewire was then placed in the center–center position in a retrograde fashion for later placement of a headless compression screw (Fig. 10.4). Wire position was confirmed by intraoperative fluoroscopy and by visualizing the pin as it traversed the nonunion site. The appropriate screw size was then determined. A tricortical autograft wedge graft was then harvested from the ipsilateral iliac crest and contoured on the back table to the proper size. An oscillating saw was then used to create a sagittal slit in the graft to allow placement of the graft over the central scaphoid K-wire (Fig. 10.5). The graft was then inserted into the defect and a derotational K-wire was placed. A compression screw was then inserted over the central guidewire and good compression was observed

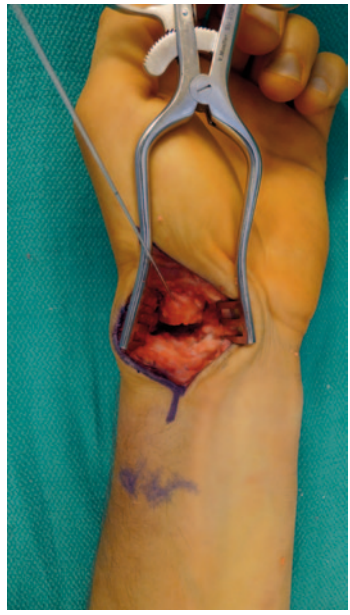

Fig. 10.4 Intraoperative photograph illustrating excavation of nonviable bone and K-wire placement. (Published with kind permission of © Roberto Diaz and James Chang, 2015. All Rights Reserved)

across the graft (Fig. 10.6, 10.7 and 10.8). The patient was immobilized in a sugar tong splint to prevent forearm rotation.

Clinical Course and Outcome

The patient returned to clinic 2 weeks following his surgery and was transitioned into a short-arm thumb spica cast. A bone stimulator was initiated to help promote bone healing. Serial X-rays were obtained at 4-week intervals to evaluate progressive bone healing. The patient was immobilized for a total of 12 weeks. Postoperative X-rays obtained at 12 weeks are shown in Figs. 10.6–10.8. A CT scan obtained at the 12-week mark confirmed near complete union of the scaphoid fracture (Fig. 10.9). Physical therapy was started at the 12-week postoperative visit. At 2 years 5 months postsurgery, the patient was working as a greenskeeper and window washer and

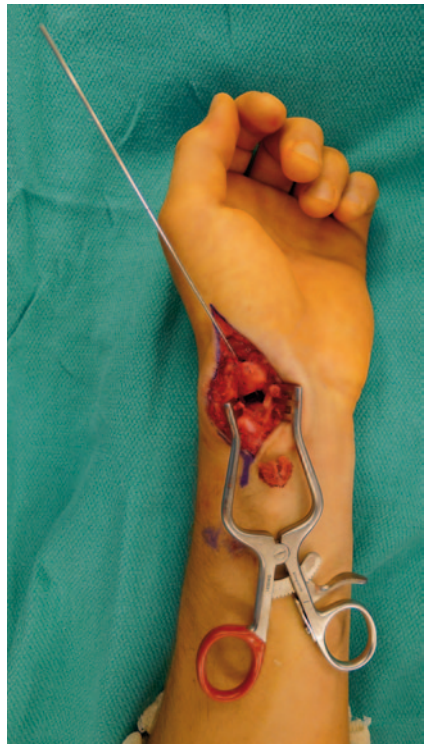

Fig. 10.5 Intraoperative photograph after preparation of iliac crest bone graft and recipient site. Note the slit in the middle of the tricortical wedge to allow for insertion over the K-wire. (Published with kind permission of © Roberto Diaz and James Chang, 2015. All Rights Reserved)

was able to perform all work duties without difficulty. Although he has not returned to competitive mountain biking, he does plan to return to this sport in the future. His patient-rated wrist evaluation total score was 6.5 and his quick disabilities of the arm, shoulder, and hand score was 2.3. Range of motion and strength in the operative and uninjured wrists were comparable as illustrated in Table 10.1.

Clinical Pearls/Pitfalls

- It is imperative that all nonviable bone be debrided from the nonunion site

Fig. 10.6 Twelve-week postoperative AP radiograph. (Published with kind permission of © Roberto Diaz and James Chang, 2015. All Rights Reserved)

Fig. 10.7 Twelve-week postoperative oblique radiograph. (Published with kind permission of © Roberto Diaz and James Chang, 2015. All Rights Reserved)

- A derotational pin is essential during placement of compression screw
- Inadequate correction of humpback deformity must be avoided and intraoperative radiographs are useful

Fig. 10.8 Twelve-week postoperative lateral radiograph. (Published with kind permission of © Roberto Diaz and James Chang, 2015. All Rights Reserved)

- Unrecognized avascular necrosis of the proximal pole of the scaphoid may be a pitfall and the need for a vascularized bone graft should be discussed with the patient preoperatively
- Postoperative immobilization should be continued until radiographic union is established via X-rays and/or CT scan
- Improper screw position and length of screw should be avoided and checked under fluoroscopy

Fig. 10.9 Twelve-week CT scan demonstrating healing and incorporation of the ICBG. *ICBG* iliac crest bone graft. (Published with kind permission of © Roberto Diaz and James Chang, 2015. All Rights Reserved)

Table 10.1 Range of motion and strength at 2 years 5 months postsurgery

	Operative left wrist	Uninjured right wrist
Wrist flexion (deg)	75	85
Wrist extension (deg)	72	77
Wrist ulnar deviation (deg)	40	45
Wrist radial deviation (deg)	30	30
Grip strenth (kg)	62	60
Key pinch (kg)	8	11
Tip pinch (kg)	13	14

Literature Review and Discussion

Scaphoid waist nonunion rates have been reported in the literature as 12 % [6]. Risk factors for the development of a nonunion include delay in treatment, proximal pole fractures, fracture displacement,

and inadequate immobilization [7–9]. The patient in this case was appropriately diagnosed with a scaphoid fracture and underwent a trial of nonoperative management with casting; however, he reported that he was only immobilized for 4 weeks. For acute nondisplaced scaphoid fractures treated nonoperatively, we generally recommend a period of 6–12 weeks of casting guided by radiographic evidence of healing. Inadequate immobilization may have played a role in the development of a nonunion in this case. We routinely obtain a CT scan as it can provide additional information to help guide treatment such as the degree of humpback deformity and the amount of bone resorption. A significant humpback deformity is best treated with structural bone graft through a volar approach. An MRI can assist the diagnosis of proximal pole AVN in which case a vascularized bone graft should be utilized. Treatment in the form of radial styloidectomy and ORIF with vascularized versus nonvascularized bone graft were discussed with the patient in detail. A radial styloidectomy was recommended as there were radial styloid changes consistent with an early stage I SNAC wrist and may have contributed to radial-sided pain. Intraoperatively, punctate bleeding was present at the proximal pole obviating the need for a vascularized bone graft procedure. Structural ICBG was preferred as it facilitates correction of the humpback deformity and because good healing rates have been reported in the literature. A large bone graft can also be obtained from the iliac crest that can later be contoured accordingly.

In 1960, Russe described the use of ICBG as an inlay technique and reported a 90 % union rate in 22 patients [10]. In this technique, a cavity is created in the proximal and distal poles of the scaphoid and a peg of ICBG is placed firmly within the cavities. However, correction of a humpback deformity is difficult to achieve using this technique. In 1984, Fernandez described a modification of the Fisk technique for the treatment of scaphoid nonunions associated with a humpback deformity [11, 12]. A corticocancellous ICBG is contoured into a wedge of bone that is placed into the nonunion site to restore scaphoid length and correct any angular deformity. The graft is then stabilized with K-wires. The author reported a 100 % union rate in 6 patients along with the normalization of the scapholunate angle. Filan and Herbert reported their experience

using a Herbert screw in the treatment of scaphoid fractures [13]. Fractures were classified according to the Herbert classification. One hundred and seven scaphoid body-type D2 and D3 fractures were treated with corticocancellous ICBG and a Herbert screw. The union rate was 76% for type D2 fractures and 58% for type D3 fractures. In 1996, Daly et al. reported their results using a similar technique with the addition of a Herbert screw for internal fixation [14]. They achieved a 95% union rate in 26 patients with a scaphoid waist nonunion treated with a corticocancellous ICBG and a Herbert screw. Our technique is similar to that described by previous authors [12–14] but differs in that we prefer to place a guidewire prior to insertion of the corticocancellous graft. Placing a guidewire prior to graft insertion allows direct visualization of the guidewire, which ensures that it is placed along the central axis of the scaphoid. The guidewire also helps distract the proximal and distal scaphoid fragments for proper sizing of the graft and facilitate graft placement. This temporary fixation also maintains correction of the humback deformity prior to graft insertion. The disadvantage of this technique is that it requires creation of a saggital slit in the graft so that it can be placed over the guidewire as it traverses the nonunion site. This saggital slit places the graft at risk for fracture. However, fracturing the graft can be avoided through proper handling of the graft during creation of the saggital slit and during graft insertion.

Scaphoid nonunions present a challenge to both the patient and the treating physician. A thorough preoperative evaluation is particularly important in patients with persistent nonunions after prior treatment. Smoking cessation should be advocated in any patient who reports tobacco use. It is important to discuss all aspects of treatment including surgical technique, period of immobilization, rehabilitation, expected outcomes, risk of nonunion, and possible need for additional procedures.

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