Chapter 17
Pediatric Scaphoid Nonunion

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Case Presentation

The patient is a 12-year-old right-hand-dominant male who injured his right wrist during a football game approximately 1 year prior to presentation. Initially, no medical treatment was sought; however, the patient had persistent limitation in motion as well as radial-sided wrist pain and therefore presented for further evaluation and treatment. The remainder of his past medical history was unremarkable.

Physical Assessment

The physical examination demonstrated tenderness to palpation about the right snuffbox. Additionally, the patient lacked 20° of wrist extension on the right side compared to the left. Wrist flexion and radial/ulnar deviation motions were symmetric. The remainder of the physical examination was unremarkable.

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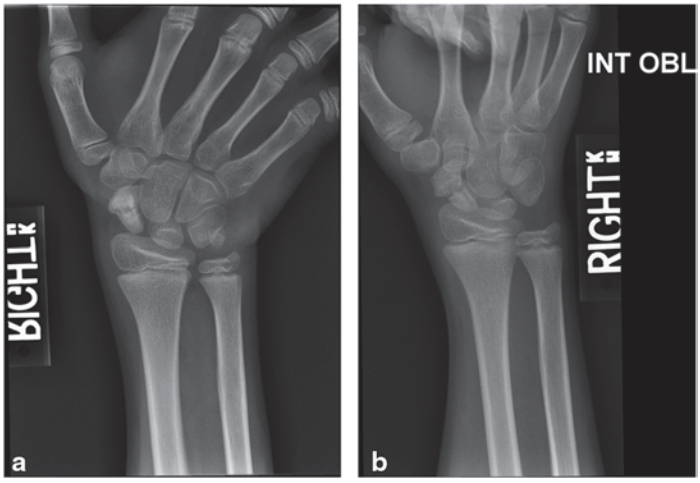

Fig. 17.1 **a** Posteroanterior and **b** internal oblique views of the *right* wrist demonstrating a scaphoid waist nonunion. (Courtesy of Shriner's Hospital for Children, Philadelphia, PA)

Diagnostic Studies

Plain radiographs demonstrated a nonunion of the scaphoid waist with the lunate in extension representing mild dorsal intercalated segmental instability (DISI) position. (Fig. 17.1a, b) A magnetic resonance imaging (MRI) study was also reviewed which confirmed a lack of bony union across the fracture site without clear evidence of avascular necrosis. (Fig. 17.2)

Management Options

Numerous surgical options exist for the treatment of pediatric and adolescent scaphoid nonunions, with all of them demonstrating excellent results. Kirschner wire fixation has been shown to be successful [1, 2]; however, more commonly compression screw fixation is now performed if the bone is large enough. [3–5] If bone

Fig. 17.2 Coronal magnetic resonance imaging (MRI) slices demonstrating the nonunion of the scaphoid waist. Note the lack of bridging bone and signal intensity present about the fracture site. (Courtesy of Shriner's Hospital for Children, Philadelphia, PA)

graft is needed to treat the nonunion, union times are increased by approximately 5 weeks, yet union rates still approach 100%. [1–7] Furthermore, if the distal radial physis is open, distal radial graft should be harvested with great care to avoid physeal bar formation and premature closure of the physis. We prefer instead to use iliac crest in these circumstances. The use of vascularized bone grafting has also been shown to have union rates close to 100%. [8] However, vascularized graft options are limited in the child with open physes. We prefer a modification of the technique described by Fernandez et al [9] that was later published by Tang et al [10] using the superficial volar branch of the radial artery.

Management Chosen

Patients that present with a chronic scaphoid fracture cannot be expected to have the same outcomes as children and adolescents that present with acute fractures and therefore casting is not recommended. Treatment with surgical reduction, bone grafting and compression screw fixation was warranted.

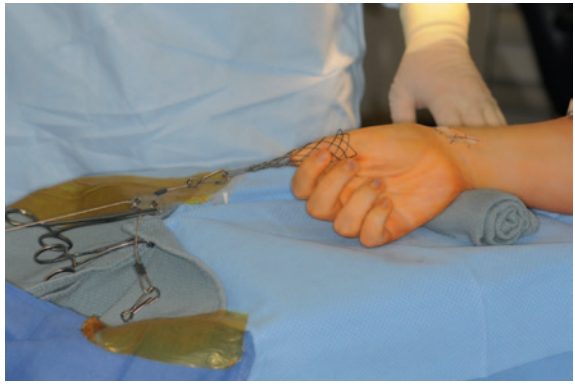

Fig. 17.3 Intraoperative photograph depicting the setup for the treatment of a pediatric scaphoid nonunion including the finger-trap applied traction. (Courtesy of Shriner's Hospital for Children, Philadelphia, PA)

Surgical Technique

The patient was brought to the operating room to undergo fixation of the scaphoid waist nonunion. A nonsterile pneumatic tourniquet was applied to the extremity, and it was then prepped and draped in the usual sterile fashion. Additionally, the ipsilateral iliac crest was prepped and draped in case autologous bone graft was needed. A Carter hand table is used to allow for traction during the procedure. The hand table attaches to a standard operating room table and has a pulley attachment at the end that fits a braided wire with a weight attachment loop on one end and a finger-trap attachment on the other end. This table allows for hands-free, constant dynamic distraction of the fracture site to open up the area of nonunion. (Fig. 17.3) The patient was placed supine and with the arm abducted 90° on the hand table, and 10 pounds of finger-trap traction was applied. A rolled towel was placed under the wrist to create wrist extension.

Initially, the wrist was flexed to permit the lunate to obtain a neutral position. Once the neutral alignment was obtained and confirmed fluoroscopically, the lunate was pinned to the distal radius utilizing a 0.062″ Kirschner wire. A modified Wagner

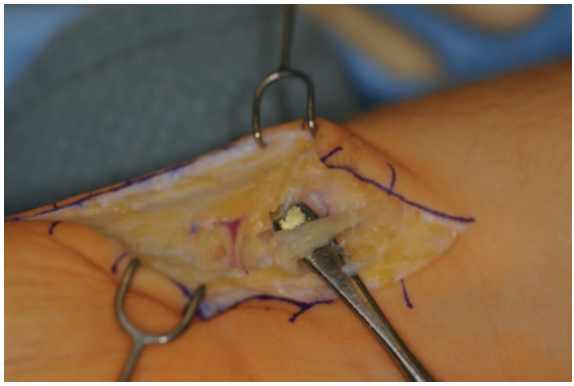

Fig. 17.4 Identification and isolation of the superficial volar branch of the radial artery. (Courtesy of Shriner's Hospital for Children, Philadelphia, PA)

approach was then performed to obtain exposure of the volar scaphoid. In an attempt to augment the vascularity of the proximal fragment, it was decided to perform a vascular pedicle transfer. The superficial volar branch of the radial artery was isolated as it crossed the surgical field. The artery was ligated distally as it entered the thenar muscles and preserved for later use (Fig. 17.4).

Approximately 25 % of the radioscaphocapitate ligament was divided to permit adequate visualization of the fracture site, which demonstrated a 3- to 4-mm gap. The nonunion site was debrided of fibrous tissue and necrotic bone. Excellent punctate bleeding was present from the distal fragment, but only minimal bleeding was present in the proximal fragment. Therefore, it was decided to proceed with autologous bone grafting of the nonunion. The previously dissected vascular pedicle was also placed into the medullary canal of the proximal fragment to augment vascularity to the nonunion site as described above. (Fig. 17.5)

Next, an oblique incision was performed directly over the ipsilateral iliac crest and dissection was carried down to the bone. A piece of tricortical graft was obtained and fashioned to fit in the defect that remained after debridement of the nonunion site. The donor wound was then irrigated and closed in layers, and attention was brought back to the wrist.

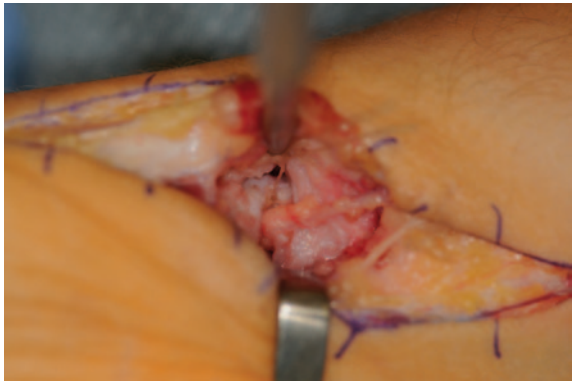

Fig. 17.5 Placement of the superficial volar branch of the radial artery into the proximal fragment medullary canal. (Courtesy of Shriner's Hospital for Children, Philadelphia, PA)

Cancellous bone from the iliac crest was packed around the vascular pedicle, and the tricortical iliac crest was placed in the defect. Once the graft was in position, a headless compression screw was placed across the nonunion site. Excellent alignment and compression were obtained. The Kirschner wire holding the lunate in neutral position was removed, and the traction was released. Lateral fluoroscopic images were obtained, and the lunate was noted to maintain its alignment in a neutral position. Following irrigation and closure of the wound, the patient was placed in a short arm thumb spica cast and awoken from anesthesia.

Clinical Course and Outcome

The patient was maintained in a cast for immobilization until fracture union, which was evident radiographically by 6 weeks postoperatively. (Fig. 17.6) We routinely see union in children at 6 weeks when using the vascular pedicle transfer. Children have

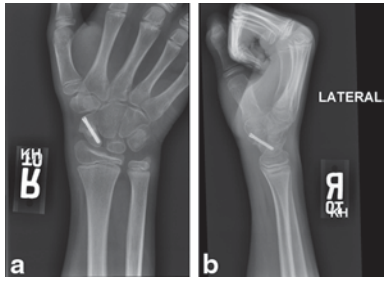

Fig. 17.6 **a** Posteroanterior and **b** lateral views of the wrist demonstrating union of the scaphoid following vascular pedicle transfer, iliac crest bone grafting, and compression screw fixation. (Courtesy of Shriner's Hospital for Children, Philadelphia, PA)

faster times to union than adults, likely due to their increased vascularity and innate ability to heal faster, even in nonunion scenarios. [3] CT scans are not obtained due to concerns of unnecessary radiation in children. At final follow-up of approximately 3 months, the patient no longer had pain and his range of motion was improving.

Clinical Pearls/Pitfalls

- Children have greater healing potential than adults
- The scaphoid is not completely ossified until around 15 years of age, creating the appearance of scapholunate widening which may be misinterpreted as a scapholunate ligament tear
- Vascularized bone grafts from the distal radius are contraindicated in skeletally immature children because of the risk of physeal bar formation
- The superficial volar branch of the radial artery is expendable and reliable, and is sacrificed routinely during the volar approach to the scaphoid

Literature Review and Discussion

Scaphoid fractures are relatively uncommon in the pediatric and adolescent population, representing less than 0.5% of all fractures. [11–13] Furthermore, the vast majority of scaphoid fractures that occur in the pediatric and adolescent population go on to union. [3, 14] Thus, a scaphoid nonunion in a child or adolescent is quite rare, occurring in 1–10% of acute pediatric and adolescent scaphoid fractures. [3, 14] Nonunions of the scaphoid are more likely to occur in this population when the fracture is not initially diagnosed. [15] This may occur due to an unimpressive physical and/or radiographic examination, or due to an inaccurate assessment of the immature carpus on imaging. [6, 16]

Treatment of a pediatric scaphoid nonunion is quite different from that of an acute fracture, as acute fractures that are nondisplaced and treated with cast immobilization have a union rate of >90%. However, chronic cases heal with cast immobilization less than 25% of the time. [3, 17–19] Attempts at treatment of chronic scaphoid fractures with casting alone is likely to result in nonunion if the fracture is at the waist or proximal pole, or if the fracture is displaced. [3] Gholson and colleagues reported that chronic fractures are approximately 30 times less likely to achieve union with casting compared to acute fractures. [3] On the contrary, union can be expected to occur in >95% of scaphoid nonunions treated with surgical intervention. [3, 20]

Results following a surgical treatment of scaphoid nonunions demonstrate good-to-excellent range of motion and the absence of pain. [1, 4, 6–8] Surgical complications following the treatment of scaphoid nonunions are extremely rare. [3, 20]

In conclusion, scaphoid nonunions in the pediatric and adolescent populations are quite rare. Prevention is of paramount importance and can occur by prompt and accurate diagnosis and treatment of acute injuries. If a scaphoid nonunion does occur, attempts at treatment with casting should be avoided due to the prolonged periods of immobilization required and a relatively low success rate (less than 25%). Surgical intervention including compression screw fixation, with or without bone grafting, yields

excellent outcomes with union rates approaching 100% and few complications in the pediatric population.

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