Scaphoid nonunion is challenging to manage because of the geometry of the scaphoid, the direction and type of fracture, and the vascular pattern of the blood supply to the scaphoid. Fracture proximal to the perforating vessels on the dorsoradial surface of the scaphoid can cause significant bone ischemia of the proximal fragment. Delayed diagnosis, inadequate initial management, proximal fracture location, osteonecrosis, and associated carpal instability with acute scaphoid fracture can lead to nonunion of the scaphoid waist or the proximal pole.  

Nonunion can exist with or without osteonecrosis of the proximal fragment. Osteonecrosis of the proximal pole can occur with a scaphoid waist nonunion, but there is almost always loss of blood supply in proximal pole scaphoid nonunion. Nonunion involving the scaphoid waist often has significant bone loss and carpal collapse, along with volar rotation of the distal pole, which produces an apex dorsal humpback deformity.

Left untreated, scaphoid nonunion can progress to carpal collapse and a predictable pattern of radiocarpal arthrosis. The goals of surgery for scaphoid nonunion include unifying the fracture and restoring carpal alignment (ie, correcting carpal instability). Evidence suggests that surgical results are better when care is taken to correct deformity and to address the vascularity of the scaphoid.

**Indications**

Cast immobilization, with or without adjunctive treatment (eg, pulsed electromagnetic fields), is not as effective as surgical intervention and typically is not recommended for managing scaphoid nonunion. Immobilization with a long arm cast for prolonged periods (>6 months) can have a significant impact on wrist and elbow motion, as well as on quality of life. Because union rates with pulsed electromagnetic fields are inferior to those with surgery, electromagnetic fields should be used only as an adjunct to surgery or when surgery is not possible. Several reports indicate that few nonunions remain stable or nondisplaced and free of arthritis after 10 years. Because of the evidence linking nonunion with osteoarthrosis, surgery is recommended for most young, healthy patients even when they are symptom-free and have normal wrist mobility. Most hand surgeons recommend open reduction and internal fixation combined with bone graft.

**Contraindications**

Surgery to correct scaphoid nonunion with bone grafting and internal fixation is contraindicated in the patient with progressive arthrosis (eg, scaphoid nonunion advanced collapse [SNAC] wrist). Relative contraindications include chronicity, location, size and vascularity of the nonunion, smoking, and patient age, all of which are important to consider when evaluating the potential for postoperative success.

**Surgical Technique**

Determining the location of the scaphoid nonunion, degree of carpal collapse, and viability of the proximal fragment is important in developing a treatment algorithm for scaphoid nonunion (Figure 1).

Plain radiographs are helpful, but not foolproof, in determining whether the scaphoid fracture involves the proximal pole. The scaphoid fracture often angles from distal volar to prox-
imal dorsal, which can be difficult to discern on plain radiography. Computed tomography (CT) may help differentiate scaphoid waist nonunion from proximal pole nonunion, especially in the presence of substantial bone resorption (Figure 2).

CT provides the most precise definition of the osseous anatomy. The sagittal images (parallel to the long axis of the scaphoid) obtained from CT scans provide the best view for determining the extent of collapse (ie, “humpback deformity”) and are helpful in planning for bone grafting procedures. Both the lateral intra-scaphoid angle (Figure 3, A) described by Amadio et al.14 and the height-to-length ratio of the scaphoid (Figure 3, B) described by Bain et al.15 can be accurately measured on CT. These measurements, obtained from sagittal images parallel to the long axis of the scaphoid, can help in accurately identifying the magnitude of collapse and angulation of the scaphoid.

The classic radiographic signs of sclerosis, cystic changes, and areas of bone resorption are not always reliable indicators of the presence of osteonecrosis associated with scaphoid nonunion. Recent studies have established the value of magnetic resonance imaging (MRI) in assessing the vascularity of the proximal pole.16-19 Low signal on both T1- and T2-weighted images seems to be associated with the greatest compromise of vascular supply. When osteonecrosis of the proximal pole has occurred and is proved by MRI findings, using traditional nonvascularized bone graft may result in poor healing rates.

Absence of T1-weighted marrow signal in proximal fragments indicates osteonecrosis (Figure 4, A), empty bone lacunae, and poor uptake of fluorescent bone labels on biopsy.19 In contrast, retention of some proximal pole signal has been associated with viable bone when examined histologically, as well as with normal uptake of fluorescent labels (Figure 4, B). Vascularized bone graft (VBG) is recommended when osteonecrosis of the proximal pole is evident on MRI.1,13,19-23

Three techniques are recommended for surgical correction of scaphoid nonunion with bone graft and internal fixation with a screw: volar, dorsal, and dorsoradial. For scaphoid waist nonunion with a viable proximal pole, the volar approach is used with interpositional wedge or inlay bone graft and screw fixation. The dorsal approach with inlay bone graft and screw fixation or a dorsoradial approach with VBG and screw fixation can be used for proximal pole nonunion with osteonecrosis of the proximal pole.

Volar Approach for Scaphoid Waist Nonunion With a Viable Proximal Pole

The volar approach is widely used for bone grafting and internal fixation of scaphoid waist nonunion. This approach allows access to the distal one third and waist of the scaphoid for nonvascularized bone grafting and retrograde internal fixation, as well as for correction of the humpback deformity that can result after scaphoid collapse. The volar approach also helps preserve the remaining dorsal blood supply. This approach is not recommended for nonunion of the proximal pole. Nonunion of the proximal pole of the scaphoid, with or without osteonecrosis, should be addressed via a dorsal approach.
General anesthesia is used routinely and is necessary when planning to harvest bone graft from the iliac crest. The patient is positioned supine with the surgical extremity on a radiolucent arm table. The arm is cleansed with antimicrobial solution and draped steriley. Exsanguination is performed with an Esmarch bandage and an inflated upper arm tourniquet. Standard screw fixation sets are used. Currently popular screws include the Herbert and Herbert-Whipple screw (Zimmer, Warsaw, IN), the Asnis III cannulated screw.
A standard Russe incision is drawn along the course of the flexor carpi radialis, extending along the border of the thenar eminence distally to the scaphotrapeziotrapezoid joint. (Reproduced with permission from Trumble TE: Fractures and dislocations of the carpus, in Principles of Hand Surgery and Therapy. Philadelphia, PA: WB Saunders, 2000, pp 90-125.)

We favor dental picks over Kirschner wire (K-wire) joysticks to avoid propagation and comminution in the fracture fragments during scaphoid nonunion reduction. Small osteotomes are used to wedge the collapsed scaphoid into its correct alignment and to resect sclerotic bone from the nonunion edges of the proximal and distal fragment. K-wires may be used to prevent rotation of fragments during drilling. A high-speed burr and fine curets are used to completely excavate the nonunion site and to remove sclerotic portions of the proximal pole. A fluoroscopy unit is used to monitor the accuracy of fracture reduction and to confirm the position of the guide wire and screw.

Step 1: Exposure

A standard Russe incision is made along the course of the flexor carpi radialis (FCR) tendon and extending distally along the border of the ulnar skin of the thenar eminence (video, Palmar Approach). The incision is extended distally to the level of the scaphotrapezial joint in preparation for screw insertion, starting in the distal pole of the scaphoid (Figure 5). Splitting the sheath of the FCR allows it to be retracted ulnarly and protects the volar cutaneous branch of the median nerve. The deep branch of the radial artery to the volar arch is retracted radially. The volar carpal ligaments (ie, radioscaphocapitate; occasionally, the long radiolunate ligament) are incised longitudinally to expose the distal pole and waist of the scaphoid (Figure 6). The fracture is evident at the proximal margin of this incision. It is important to preserve as much as possible of the radioscaphocapitate ligament because this ligament helps to contain the proximal pole and prevent it from translating or subluxating volarly.30,31 When using cannulated screws (rather than the standard compression jigs), it is not necessary to freely divide the radioscaphocapitate ligament.

In the patient with nascent nonunion (ie, nondisplaced scaphoid fracture that does not show adequate healing after 3 months of proper immobilization), a volar limited approach may be used. The limited Russe approach is used to expose the scaphotrapezial joint. The volar beak of the trapezium is removed, followed by percutaneous screw fixation with bone grafting.

Step 2: Correction of Humpback Deformity

The humpback deformity must be corrected to allow stable screw fixation in the long axis of the scaphoid and to prevent arthro-
Small osteotomes are used to obtain acceptable alignment on correction of the collapsed scaphoid. Care must be taken not to disrupt the dorsal cortex of the scaphoid. Such disruption could damage any remaining blood supply to the proximal pole and make the fracture highly unstable.

Full excavation of the nonunion site and removal of sclerotic portions of the proximal pole are accomplished using fine curets and a high-speed bur with saline irrigation. Reduction of the nonunion is achieved using dental picks or single hook retractors. The reduced scaphoid is stabilized with K-wire.

When approached volarly, the inner wall of the dorsal cortex can be notched to accommodate the wedge graft. Great care should be taken, however, to avoid complete penetration of the dorsal cortex. The continuity of the dorsal cortex serves as a hinge around which the distal fragment can be rotated on wrist dorsiflexion during the reduction. Complete disruption of the dorsal cartilage and fibrous tissue can make the nonunion extremely unstable and allow the bone graft to be displaced dorsally. Because screw fixation offers significant stability, we often use a cancellous bone graft rather than a corticocancellous one. However, when large segments of the volar cortex are missing, the corticocancellous graft improves stability, especially if it can be compressed with the scaphoid screw.

**Step 3: Screw Fixation**
Removing the small volar beak or foot process of the trapezium with a small rongeur provides sufficient access for insertion of a compression screw into the long axis of the scaphoid so that the proximal screw threads are centered in the central one third of the proximal pole (Figure 7). Failure to do so can result in a screw that is placed too dorsal near the fracture line. The guide wire is inserted into the central axis of the scaphoid up to the limits of the subchondral bone of the proximal pole to determine the length of the screw.

Next, the guide wire is driven into the radius to prevent it from dislodging (Figure 8). Placing the screw in the center of the proximal pole ensures the most stable fixation possible of the nonunion.

Next, the cannulated drill and tap are used to prepare the path for the screw; progress is monitored using fluoroscopy. Once the screw is inserted, the guide wire is removed, and plain radiographs are obtained to confirm the position of the screw. The volar wrist capsule is repaired with interrupted sutures, especially that portion of the radioscaphocapitate ligament that had been incised. The remaining soft tissues (eg, FCR sheath) fall naturally back into place when traction is released. The subcutaneous layer and skin are closed in separate layers.

**Rehabilitation and Postoperative Management**
Two weeks after surgery, the splint and sutures are removed, and a short arm cast is applied for 1 month. Subsequently, the patient is placed in a custom-molded removable splint until union is confirmed radiographically. Once the patient is in the removable splint, protected range-of-motion exercises are begun.

**Outcomes**
Recent reports of bone grafting and internal fixation of scaphoid nonunion describe >90% union rates, with fairly rapid healing that reduces the need for prolonged immobilization. In the authors’ series, patients regained 80% of the motion of the contralateral wrist and >70% of the strength of the contralateral hand. Ninety percent of the patients with painful scaphoid nonunion reported a notable decrease in wrist pain.

**Dorsal Approach for Scaphoid Nonunion With a Viable Proximal Pole**
The scaphoid nonunion with a viable proximal pole is usually managed with nonvascularized bone grafting and internal fixation via a...
dorsal approach. The purpose of the dorsal approach is to remove the avascular bone from the proximal pole and to achieve stable screw fixation without either displacing the small proximal fragment or compromising the remaining vascular supply. The fracture line of a nonunion frequently occurs from distal volar to proximal dorsal; thus, a screw placed from volar may not cross the nonunion and can displace the proximal pole fragment. With the dorsal approach, the surgeon can place the screw into the central portion of the proximal pole fragment (Figure 9).

Realizing that the vascular supply of the proximal fragment has already been significantly compromised by a fracture mitigates, but does not eliminate, concerns that a dorsal approach might further threaten its vascularity.

One contraindication to this approach is scaphoid waist nonunion; this type of fracture should be approached volarly. Osteonecrosis of the proximal pole should be managed with VBG.

**Surgical Setup/Instrumentation**

Patient positioning and instrumentation are the same as described for the volar approach.

**Step 1: Exposure**

A small longitudinal incision is made in the midline of the wrist; this incision is centered over the radiocarpal joint. The sheath of the extensor pollicis longus tendon is released. The capsule and fourth dorsal compartment are sharply dissected off the dorsal lip of the radius. A longitudinal incision over the radiocarpal joint capsule is made to expose the scapholunate articulation. On wrist flexion, the entry site for the screw appears just adjacent to the exposed scapholunate interosseous ligament.

**Step 2: Guidewire Insertion**

A small needle may be used to locate the plane of nonunion. Fine curets and a high-speed burr are used to remove the necrotic bone. The guidewire for the cannulated screw can be inserted to the level of the subchondral bone of the proximal pole, which allows proper placement of the screw into the central portion of the proximal pole fragment. (Reproduced with permission from Trumble TE: Fractures and dislocations of the carpus, in Principles of Hand Surgery and Therapy. Philadelphia, PA: W B Saunders, 2000, pp 90-125.)
pezium to prevent it from being dislodged during drilling and tapping (Figure 10). Often, a second K-wire is placed to prevent rotation or displacement of the proximal pole fragment during screw insertion.

**Step 3: Screw Fixation**
After the guidewire is driven up into the trapezium, the path of the screw is prepared by drilling and tapping. The screw can be inserted either freehand or by using the guidewire. In small proximal pole fragments, we prefer to remove the guide wire and insert a noncannulated Herbert screw (Zimmer) because it leaves a smaller defect (footprint) in the cartilage of the proximal pole. The capsule is closed with absorbable sutures. The third dorsal compartment is not repaired, and the subcutaneous tissue and skin are closed in subsequent layers.

**Rehabilitation and Postoperative Management**
Generally, we use the same postoperative management protocol as with the volar approach.

**Outcomes**
The prognosis for the patient with proximal pole nonunion is more guarded than for the patient with scaphoid waist nonunion. The time to union is 2 to 3 months longer for proximal pole nonunion. For the patient with nonunion of the proximal pole, there is a reported union rate of 67%, versus a union rate of 87% for scaphoid waist nonunion.36

**Dorsal Approach With Vascularized Bone Graft for Scaphoid Nonunion With Osteonecrosis of the Proximal Pole**
**Evolution of Vascularized Graft**
Healing of proximal pole scaphoid nonunion can be achieved with stable internal fixation and bone grafting.32,34 The rate of healing correlates directly with the vascularity of the proximal pole.37 Unfortunately, fibrous union and persistent nonunion tend to develop when osteonecrosis of the proximal pole is present. Such conditions are often refractory to traditional bone grafting methods, even when augmented with internal fixation. Theoretically, the use of pedicled VBGs, which help revascularize ischemic bone, should improve the union rate and time to union.22 A recent meta-analysis of treatment of scaphoid nonunion with osteonecrosis of the proximal pole indicated an 88% union rate with a VBG, compared with a 47% union rate with nonvascularized bone graft.36

Early vascularized grafts were often based on a pedicle from the pronator quadratus insertion on the distal radius.38,39 Recently, several VBG sources have been described, including the ulnar artery,40 the volar carpal artery,41,42 vascularized periosteal flaps of the distal radius,20,43 the capsular-based flap vascularized graft,23 a combination of inlay corticocancellous bone graft with implantation of the second dorsal intermetacarpal artery,44 and even a free vascularized graft from the iliac crest.45 At present, the most frequently used donor sites include the dorsoradial aspect of the distal radius (first described by Zaidemberg et al46) and the second metacarpal graft.21,47

The VBG described by Zaidemberg, the technique presented in this article, relies on the superior retinacular branch of the radial artery,46 which Sheetz et al48 have defined as the 1,2 intercompartmental supraretinacular artery (1,2 ICSRA). This artery travels in a distal-to-proximal direction along the retinaculum between the tendons of the first and second dorsal compartment. The 2,3 ICSRA may also be used in select patients in whom the 1,2 ICSRA is small or absent. These vascularized grafts can be harvested through the same dorsal approach used for internal fixation of the scaphoid nonunion.

Indications for the use of VBG include scaphoid waist or proximal pole nonunion with associated osteonecrosis. The primary contraindication is the presence of a viable proximal pole,
as demonstrated on MRI. As with the scaphoid waist fracture, the procedure is also contraindicated in the presence of severe concomitant arthroses (SNAC stage II or greater).

**Surgical Setup/Instrumentation**

Surgical setup and patient preparation are the same as described previously. However, microsurgical instruments, including vessel loops and special bone tamps, are needed for harvesting the small vascular pedicle grafts.

**Step 1: Exposure**

The dorsoradial approach, an extension of the dorsal approach for the viable proximal pole, allows graft harvesting as well as exposure of the scaphoid nonunion (Figure 11; video, Vascularized Bone Graft). The midline incision over the dorsal aspect of the wrist curves proximally and radially over the interval between the first and second dorsal compartments. The third dorsal compartment is released, and the extensor pollicis longus tendon is retracted radially. The sensory branch of the radial nerve is identified exiting from between the brachioradialis and the extensor carpi radialis longus muscles. The extensor carpi radialis longus is retracted ulnarly. The 1,2 ICSRA is visible as a thin red line in the groove between the first and second dorsal compartments. The vessel takes off distally from the radius and pierces the volar wall of the first dorsal compartment. The first dorsal compartment is rolled along its volar surface, and the tendons are retracted. The arterial pedicle is mobilized by making parallel incisions in the periosteum between the two compartments, tracing the course of the artery from distal to proximal. After preparing a 2.0- to 2.5-cm pedicle, the periosteum around the planned donor site is incised as an ellipse or rectangle. A fine oscillating saw, with constant irrigation, is used to cut the three sides of the graft, excluding the side under the vascular pedicle. Small osteotomes are used to complete graft elevation (Figure 12).

**Step 2: Graft Placement**

Preparation of the scaphoid nonunion site and complete removal of necrotic bone can be done with fine curets and a high-speed burr, guided by fluoroscopic imaging (Figure 13). After preparation of the nonunion site, the tourniquet is released to observe bleeding from the graft. The vascularized graft is then rotated into the defect and secured with either K-wires or a screw (Figure 14).

**Step 3: Screw Fixation and Closure**

Screw fixation in combination with bone grafting has significantly better union rates ($P = 0.004$) than K-wire fixation in combination with bone grafting. Screw fixation with

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**Figure 11**

The dorsoradial incision for the dorsal approach to the nonunion site of the scaphoid is drawn, including harvesting VBG from the distal radius. Proximal and radial extension of the midline incision over the dorsal aspect of the wrist is demonstrated.

**Figure 12**

A, Intraoperative photograph demonstrating the parallel incisions in the periosteum between the first and second extensor compartments, tracing the course of the 1,2 ICSRA from distal to proximal. This incision is used to mobilize the arterial pedicle. B, The three sides of the graft (excluding the side under the vascular pedicle) are cut by a fine oscillating saw. The graft is elevated completely using small osteotomes.
bone grafting also provides stability, which can reduce the time needed for immobilization. Screw fixation can be performed with a technique similar to that described for the dorsal approach (Figure 15). The capsule is closed loosely to avoid strangulation of the vascular pedicle. The subcutaneous tissues and skin are closed in layers.

Rehabilitation and Postoperative Management

Rehabilitation after either vascularized or nonvascularized bone grafting of scaphoid nonunion is similar. For vascularized bone grafting, we recommend a longer period of casting for 2 months after the sutures are removed, followed by splinting until union is achieved. The patient is restricted from all lifting until union. Because of the longer times to union and the lower rate of successful healing, a bone stimulator is added in patients in whom previous surgery failed, who had delayed treatment (>2 years), or who had marked necrosis of the proximal fragment that was detected intraoperatively. A bone stimulator is used during postoperative cast immobilization, from the immediate postoperative period until 4 months or until union. Ricardo49 reported significant (P < 0.0001) acceleration of healing (average, 38 days) with use of a bone stimulator.

Outcomes

Union was achieved in all 11 patients in the study by Zaidemberg et al.46 Several other researchers have reported union rates approaching 100%.1,50,51 Chang et al13 reported a 72% union rate in a large case series. In several of the original studies, a concomitant volar approach was required to fully address the flexion deformity of the distal scaphoid fragment. This is usually necessary in scaphoid waist fractures with a severe humpback deformity. More recently, we have rotated the vascular pedicle into a volar defect through a single approach. Vascularized grafting clearly has a role in the management of scaphoid nonunion with osteonecrosis or with scaphoid nonunion that proves to be refractory to traditional grafting.

Complications

Persistent Nonunion

Persistent nonunion may require a second bone grafting procedure or VBG. Collapse of the small proximal

Figure 13

A, A high-speed burr is used to remove necrotic bone within the proximal pole of the scaphoid. B, Further removal is done with a small curet.

Figure 14

After the tourniquet is released, the vascular graft is held with Adson forceps (Anthony Products, Indianapolis, IN). A, The appearance of bleeding from the cancellous bone of the vascularized graft. B, The vascularized graft is trimmed, mobilized, and rotated into the nonunion site.
fragment can result in degenerative radiocarpal arthritis, requiring salvage surgery.

**Hardware Malpositioning**
Improper positioning of screws in the scaphoid can lead to failure of compression and further delay healing when the threads do not cross the fracture nonunion site. A screw that penetrates the articular surface may put the patient’s wrist at risk for iatrogenic arthritis.

**Stiffness**
Further restriction of wrist range of motion may be found after bone grafting and internal fixation of scaphoid nonunion.

**Pain**
Postoperative pain is a byproduct of any bony procedure about the wrist. However, these procedures may result in continued postoperative pain at an increased level, par-

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**Pearls and Pitfalls**

**Volar Approach**

**Pearls**
- As much as possible of the radioscapohipitate ligament should be preserved to help control the proximal pole and prevent it from subluxating volarly.
- The humpback deformity must be corrected to allow for stable screw fixation in the long axis of the scaphoid and to prevent arthrosis.14,30
- Small osteotomes are used to wedge the collapsed scaphoid into correct alignment. Care must be taken not to disrupt the dorsal cortex of the scaphoid, which can damage the remaining blood supply to the proximal pole and make the fracture highly unstable.
- During excavation of the nonunion site, dental picks or single skin hooks are favored over K-wire joysticks to gain fracture reduction and to avoid fracture line propagation and comminution of the fracture fragments.

**Pitfalls**
- On plain radiographs, the extension of nonunion into the proximal pole of the scaphoid must be identified. Adequate fixation in the small proximal pole fragment may not be achieved with the volar approach. A preoperative CT can help avoid this problem.
- Failure to correct the volar collapse of the scaphoid leads to increased incidence of arthritis and decreased wrist motion.14,31 A wedge-shaped graft can correct scaphoid alignment and enable stable screw placement without cutting out volarly.
- Osteonecrosis of the proximal pole must be identified before surgery. A preoperative MRI can help identify osteonecrosis that is not seen on plain radiographs, thus allowing preoperative, rather than intraoperative, planning for VBG.19
- The lateral volar surface of the trapezium must be properly prepared for a volar approach. The prominent volar lip of the trapezium forces the surgeon to place the screw too dorsal in the proximal pole of the scaphoid. Removing this lip before placing the guidewire allows accurate centering of the screw into the long axis of the scaphoid.
- The continuity of the dorsal cortex must be maintained when notching the inner wall to accommodate the wedge graft. Complete disruption of the dorsal cartilage and fibrous tissue can cause extreme instability of the nonunion.
- Failure to achieve accurate screw placement with internal fixation can result in an unstable construct, with the potential for a lower rate of union.30 The use of fluoroscopy and cannulated screws improves the accuracy and success of internal screw fixation.
particularly when surgery to correct nonunion is performed in the relatively asymptomatic patient.

Nerve Injury

In the volar surgical approach, the median nerve and its volar cutaneous branch are at risk for injury. In the dorsal approach, especially when harvesting a dorsoradial VBG, the radial sensory nerve is at risk.

Summary

Surgical techniques for the management of scaphoid nonunion are much more demanding than those for acute fracture because they must address anatomic changes, such as bone resorption, carpal collapse, and osteonecrosis. The location of the nonunion site and viability of the proximal fragment are the critical factors in determining surgical approach.

Scaphoid waist nonunion without osteonecrosis warrants the volar

### Dorsal Approach for Scaphoid Nonunion With a Viable Proximal Pole

**Pearls**

- Care should be taken to preserve the tissue on the dorsal ridge of the scaphoid in an attempt to preserve as much as possible of the remaining scaphoid blood supply, which is already significantly compromised by the fracture.
- The surgeon should use an insertion point that is close to the scapholunate interosseous ligament attachment to the scaphoid. The screw should be targeted distally toward the scaphoid tubercle.
- The screw must be adequately countersunk because insertion is performed in the center of the articular surface of the proximal pole. To avoid problems in countersinking the screw, undersize the screw by 3 to 4 mm.

**Pitfalls**

- Failure to identify the exact location of the scaphoid nonunion that extends into the proximal pole can lead to an incorrect surgical approach.
- Failure to identify osteonecrosis of the proximal pole during preoperative planning can result in being unprepared for VBG at the time of surgery.
- Failure to control the proximal fragment during drilling, tapping, or screw insertion can result in further displacement of the fracture and lead to inaccurate fixation. Using temporary K-wire fixation to control rotation can stabilize the nonunion during this process.

### Dorsal Approach for Vascularized Bone Graft for Scaphoid Nonunion With Osteonecrosis of the Proximal Pole

**Pearls**

- The tissue on the dorsal ridge of the scaphoid should be preserved because of its potential for bringing blood supply to the scaphoid. Implants should be adequately countersunk in the proximal pole of the scaphoid.
- We recommend harvesting the VBG before débriding the scaphoid. This allows the surgeon to gauge the size of the window in the scaphoid that must be prepared.
- We first inspect for the presence of the artery of Zaidemberg; the second dorsal metacarpal artery can be used as an alternative in ≤5% of patients.
- Additional cancellous bone graft is harvested from the bed of the VBG in the distal radius and is packed into the crevices of the scaphoid defect before tamping in the VBG.
- When the VBG does not fit into the defect in the scaphoid, our first choice is to enlarge the defect of the scaphoid rather than risk damaging the vascular pedicle by resizing the graft.
- To improve exposure and decrease tension in the vascular pedicle, radial styloidectomy is frequently performed.
- The patient with significant deformity and collapse from a long-standing scaphoid waist nonunion with osteonecrosis may require a more complex procedure that entails rotating the VBG along the radial and volar aspects of the scaphoid after radial styloidectomy. A standard volar wedge graft may be required in addition to the VBG.

**Pitfalls**

- Failure to identify osteonecrosis of the proximal pole before surgery, to correct the humpback deformity of the scaphoid, and to accurately place screws used for internal fixation of the scaphoid can result in decreased rates of union.
approach. The dorsal approach is used to enable bone grafting and accurate screw placement for non-union of the proximal pole of the scaphoid. When osteonecrosis of the proximal pole is detected on MRI, a VBG from the distal radius (using a dorsoradial approach) is recommended. Correction of humpback deformity is best achieved by a volar surgical approach with bone grafting and internal fixation using supplemental K-wire or a compression screw. Salvage procedures, such as proximal row carpectomy, scaphoid-screw. Salvage procedures, such as symptomatic injury.

References

Citation numbers printed in bold type indicate references published within the past 5 years.


