The use of vascularized bone grafts to treat scaphoid nonunion has been proposed by various investigators. We examined the blood supply to the palmar surface of the distal radius in 40 fresh cadavers that were injected with a colored latex solution and determined that the radial portion of the palmar carpal arterial arch can serve as a pedicle for vascularized grafts. Scaphoid nonunions with a humpback deformity can be corrected by harvesting a wedge of vascularized bone from the palmar cortex of the distal radius, providing easier access to the scaphoid deformity compared with the use of dorsal distal radius vascularized grafts. We also review our series of 72 patients treated by this technique.

Nonvascularized autogenous bone grafts combined with internal fixation have become the preferred treatment for scaphoid nonunions for many surgeons. In 1965 Judet and Roy-Camille1 suggested using a bone graft harvested from the palmar aspect of the radius with a vascular supply from fibers of the pronator quadratus muscle. Braun2 and Kawai and Yamamoto3 reported excellent results in treating scaphoid nonunions by using this source of vascularized bone. Other vascularized grafts from the radial and dorsal aspects of the wrist and hand have been described, with similarly encouraging results.4-11 In this review, we describe the technical aspects of the vascular supply to the palmar aspect of the radius based on cadaver dissections and report on our experience using a vascularized palmar graft in a series of patients with scaphoid nonunions.

Anatomic Basis for Volar Vascularized

Inspired by the work of Kuhlman et al,12 we describe a vascularized graft harvested from the anterior aspect of the radius based on the volar carpal artery. This pedicle is long enough to reach the scaph
oid without excessive tension (Fig 1). An arterial network located on the palmar aspect of the distal radius and ulna perfuses the graft. In 40 cadaver dissections, we were able to confirm the presence of a volar carpal artery. This vessel originates from the radial artery at the level of the radial styloid and runs along the palmar aspect of the radius (Fig 2). The artery follows the distal edge of the pronator quadratus and forms a “T”-shaped anastomosis with the anterior interosseous artery adjacent the distal radio ulnar joint (Fig 3). After branching from the radial artery, the volar carpal artery travels along the radial third of the distal radius and penetrates the radius at the radial epiphysis.
Harvesting Vascularized Bone

Dissection of small arteries may result in damage to the vessel unless it is harvested with a cuff of adjacent tissue. The volar carpal artery has a predictable location between the periosteum of the radius and distal margin of the radius. Fibrous tissue and devascularized bone are removed from the site of the nonunion using a small curved curette. Restoring the scaphoid to its appropriate length is facilitated by traction on the thumb and by using a narrow osteotome to separate the 2 poles of the scaphoid at the nonunion site. Intraoperative radiographs can help confirm the adequacy of the reduction. The dimensions of the defect in the scaphoid are measured while the osteotome maintains separation of the fracture fragments. If necessary, the provisional reduction can be maintained by placing a pin through the distal pole of the scaphoid into the capitate and a second pin through the proximal pole into the lunate.

TECHNIQUE

The scaphoid and radius are exposed in the interval between the radial artery and the tendon of the flexor carpi radialis (Figs 4, 5, and 6). With the wrist in extension and ulnar deviation, the anterior capsule is reflected, exposing the scaphoid and distal margin of the radius. Fibrous tissue and devascularized bone are removed from the site of the nonunion using a small curved curette. Restoring the scaphoid to its appropriate length is facilitated by traction on the thumb and by using a narrow osteotome to separate the 2 poles of the scaphoid at the nonunion site. Intraoperative radiographs can help confirm the adequacy of the reduction. The dimensions of the defect in the scaphoid are measured while the osteotome maintains separation of the fracture fragments. If necessary, the provisional reduction can be maintained by placing a pin through the distal pole of the scaphoid into the capitate and a second pin through the proximal pole into the lunate.

Harvesting Vascularized Bone

Dissection of small arteries may result in damage to the vessel unless it is harvested with a cuff of adjacent tissue. The volar carpal artery has a predictable location between the periosteum of the radius and distal margin of the pronator quadratus. The fascia and muscle of the pronator quadratus are incised 1 cm from its distal margin along the full width of the muscle. The periosteum is incised along the distal and proximal margins of this 1-cm strip of fascia and muscle. The radial half of this strip is elevated, with
FIGURE 8. Harvesting the graft using osteotomes (A). XXXXXXXXXXXXXXXXXXXXX (B).


FIGURE 10. (A, B) The graft fills the palmar defect without excessive tension on the pedicle (A). XXXXXXXX (B).
5-mm osteotomes (Fig 8). The graft and its pedicle then are dissected to the origin of the volar carpal artery. The most lateral attachments of the pronator quadratus fascia can be divided without hesitation to create a 4- to 5-cm pedicle.

The scaphoid is stabilized with a screw inserted anteriorly and directed distal to proximal. The screw its periosteum off the palmar cortex of the radius, by using a combination of scalpel and osteotome (Fig 7). Dimensions of the graft are marked on the radius, and the graft is harvested using 10-mm osteotomes. The axes of the osteotome are oblique on the distal and proximal part of the graft to create a pyramid-shaped graft. The pedicle and bone are elevated using two 5-mm osteotomes (Fig 8). The graft and its pedicle then are dissected to the origin of the volar carpal artery. The most lateral attachments of the pronator quadratus fascia can be divided without hesitation to create a 4- to 5-cm pedicle.

The scaphoid is stabilized with a screw inserted anteriorly and directed distal to proximal. The screw
is inserted as dorsal as possible to minimize interfering with placement of the graft. We also avoid the scapho trapezial joint to avoid future discomfort (Fig 9).

The bone graft is placed to fill the defect on the palmar aspect of the scaphoid. If the surgeon is successful in matching the graft to the defect, no additional graft is necessary. Small residual defects can be filled with cancellous bone from the distal radius. The graft can be stabilized by tightening the screw or with a pin inserted from the distal tubercle into the graft. This pin should be parallel to the screw to avoid damaging the vascular pedicle (Fig 10).

The capsule, particularly the radioscapophocapitate ligament, is repaired with care to avoid compressing...
the pedicle. The skin is closed over a suction drain. The wrist is immobilized in a palmar short-arm splint with the wrist in about 40° of extension. If a pin is used to stabilize the graft, it is removed in 3 weeks. Wrist immobilization is continued until there is radiographic and clinical evidence of union.

**OUR EXPERIENCE**

We used a volar vascularized bone graft in a series of 72 patients presenting with scaphoid nonunions and a significant humpback deformity, which we believed would be difficult to treat using vascularized bone grafts from the dorsal distal radius because of pedicle length. Average time to union was 60 days, based on the radiographic appearance. Representative cases are illustrated in Figs 11 and 12.

**CONCLUSION**

Anatomic dissections and our clinical experience have shown the utility of vascularized bone grafts based on the volar carpal artery to treat scaphoid nonunions. Graft harvested from the palmar aspect of the radius facilitates correction of the humpback deformity that frequently is seen in scaphoid nonunion. Although this technique was described initially for persistent nonunion after surgical treatment, the rate of union and ultimate wrist function compels us to propose palmar vascularized bone grafts as a primary treatment for scaphoid nonunion.

**REFERENCES**