A new vascularized bone graft for scaphoid nonunion

Nonunion and avascular necrosis after scaphoid fractures continue to be problem sequelae because of unrecognized injuries, inadequate immobilization techniques, or insufficient treatment time. Screw fixation and inlay bone grafting techniques remain the options of choice, with successful union reported in approximately 90% of patients. However, prolonged immobilization with plaster up to 4 to 6 months is required with conventional techniques. With the use of standard latex injection techniques with vascular filling of vessels to less than 0.1 mm diameter in ten fresh cadaver dissections, we discovered a consistent vascularized bone graft source from the distal dorsoradial radius. We have used this vascularized bone graft source with good results in eleven patients with long-standing nonunion of the scaphoid. It is technically easy and seemingly offers the advantages of a decreased period of immobilization and a higher union rate. (J HAND SURG 1991;16A:474-5)

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Nonunion and avascular necrosis after scaphoid fractures continue to be problem sequelae primarily because of unrecognized injuries, inadequate immobilization, or insufficient treatment time. Until recently screw fixation and inlay bone grafting techniques were the options of choice, with successful union reported in approximately 90% of patients. Avascular necrosis and arthritic degeneration are minimized with adequate union of the scaphoid. Vascularized bone grafts easily pedicled to the proximal carpus have been recently described. Kawai and Yamamoto modified the pronator quadratus pedicled bone graft from the distal radius first described by Braun and Chacha and applied it to old scaphoid fractures in eight patients. Kuhlmann and associates reported their experience with vascularized bone graft pedicled on the palmar carpal artery for nonunion of the scaphoid in three patients. We report a new pedicled vascularized bone graft from the dorsum of the distal radius and its use in eleven cases of long-standing nonunion of the scaphoid.

Anatomic study

Standard latex injection techniques were used in 10 fresh cadaver dissections (20 wrists) allowing visualization of vessels to less than 0.1 mm in diameter. After stripping of the vessel wall a latex cast of vessel lumen remains. A consistent retrograde branch from the radial artery provides blood supply to the dorsoradial aspect of the distal radius (Fig. 1, A and B). At the level of the radiocarpal joint, a branch of the radial artery ascends deep to the first dorsal extensor compartment. The irrigating vessel turns to lie on the dorsoradial aspect of the distal radius at the level of the radial styloid. A bone graft incorporating the overlying vascular pedicle and periosteum can easily be harvested and transposed into the scaphoid recipient site (Figs. 2 and 3). The periosteal vessel continues into the skin so that a monitoring island of skin can also be raised (Fig. 4, A and B). This anatomic arrangement was found in all 20 cadaver dissections.

Surgical procedure

A dorsal approach provides easy exposure. Although we prefer palmar approaches to the carpus in general, the advantages of this vascularized bone graft source warrant the dorsal approach. The topographical anat-
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Fig. 1. A, Anatomic dissection of right cadaver wrist with vessel walls stripped leaving only latex casts of lumen. B, Corresponding drawing to anatomic dissection.

Fig. 2. Mobilized vascular bone graft on its vascular pedicle.
Fig. 3. Transposed vascularized bone graft in scaphoid recipient site in anatomic dissection.

Fig. 4. A. Intraoperative dissection of vascularized bone graft with associated monitoring skin island. Note the continuing periosteal blood vessel entering the skin island. B. Monitoring skin island 1 week after operation reflecting a viable vascularized bone graft in another patient.
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An oblique incision on the radiodorsal aspect of the wrist is made. Care must be taken to avoid injury to branches of the dorsal sensory branch of the radial nerve. The extensor retinaculum is divided. The first dorsal compartment containing the extensor pollicis brevis and abductor pollicis longus tendons is retracted palmarly. The extensor carpi radialis longus and finger extensor tendons are reflected ulnarly. The longitudinal course of the irrigating vessel is easily identified overlying the distal radius. A vascularized bone graft is designed centering this perfusing periosteal blood vessel over the bone to be harvested. Next, the nonunion of the scaphoid is visualized and the sclerotic bone ends are freshened with a power drill. The fracture is reduced. If adequate reduction of the scaphoid fracture cannot be achieved, then a combined palmar approach may be necessary to first reduce the scaphoid fracture before bone grafting. A trough 15 to 20 mm in length is fashioned running parallel to the long axis of the scaphoid. A bone graft corresponding in size to the cavity created in the scaphoid bone is then harvested from the distal radius underlying the vascular pedicle. The bone graft is then easily transposed to the recipient scaphoid site (Fig. 3). The bone graft is secured in place with Kirschner wires. If additional cancellous bone graft is needed, it can be harvested through the same distal radius site.

The skin is closed and a long arm cast with thumb spica is applied for 1 month, followed by a short arm cast with thumb spica for 2 weeks.

We have documented vascularity of our bone graft by bone scans obtained at 5 days after operation or by incorporating the accompanying skin island.

At 6 weeks, union is assessed by radiographs. Tomograms are obtained if any doubt exists concerning union. When stable bony union is certain, range of motion exercises are started.

Clinical experience

In all 11 patients the indications for vascularized radial bone graft was long-standing pseudoarthrosis of the scaphoid associated with chronic wrist pain. There were 9 men and 2 women. Their ages ranged from 18 to 56 years (average, 26.2 years). Surgery was done from 5 months to 11 years after injury (average, 2 years 3 months). All patients exhibited decreased power grip and range of motion compared with the contralateral side.

Fractures had been initially missed in 5 patients. Two patients were noncompliant with the length of proposed immobilization, and 2 patients failed to achieve radio-
Table I. Preoperative and postoperative average range of motion and grip strengths

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<tr>
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<th>Before operation</th>
<th>After operation</th>
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<tr>
<td>Wrist extension</td>
<td>40°</td>
<td>70°</td>
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<tr>
<td>Wrist flexion</td>
<td>30°</td>
<td>60°</td>
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<td>Radial deviation</td>
<td>10°</td>
<td>20°</td>
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<td>Ulnar deviation</td>
<td>10°</td>
<td>20°</td>
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<td>Grip strength (compared with the contra-lateral hand)</td>
<td>70%</td>
<td>95%</td>
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graphic union after 4 and 6 months of immobilization. Five patients had failed conventional Matti-Russe types of cancellous bone grafting with appropriate lengths of immobilization. Two patients exhibited sclerotic changes in the distal radius at the radiocarpal joint before operation.

Results

All 11 cases exhibited radiographic union. The average length of immobilization to radiographic and clinical union was 6.2 weeks (range, 5 to 8 weeks) (Fig. 5, A and C). Chronic wrist pain at rest was completely relieved in all patients. Pain with motion was markedly diminished in all patients and eliminated in six. The average range of motion and grip strength of the wrist improved after surgery (Table I).

Discussion

Nonunion of the scaphoid continues to be treated by prolonged plaster immobilization, internal fixation with or without cancellous bone grafting, and pulsed electromagnetic fields. Despite these options, successful union is not obtained in up to 10% of patients. Conventional bone grafting techniques had failed in approximately one half of the patients in our series.

Although our number of cases is small, this treatment of scaphoid nonunion with vascularized bone graft offers the advantages of a shorter period of immobilization and an apparently higher union rate. The dorsal approach for vascularized bone grafts for scaphoid nonunion is new and offers the reconstructive surgeon a technically easy option compared with vascularized bone sources previously described from the volar aspect of the distal radius. Vascularized bone graft offers distinct advantages, and the bone graft site we have described should be considered in cases of long-standing scaphoid nonunion, cystic degeneration of the scaphoid, or in limited carpal fusions on the radial side of the wrist.

References